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## THE MODERN GOLD SHIP. HOW IT HAS INVADED THE LAND OF CALIFORNIA.

BY GEORGE ETHELBERT WALSH.

THE modern gold dredge is one of the most important factors in gold mining of to-day, and it is rapidly changing conditions in mining districts where the bedrock is soft and the gold fine and easily amalgamated. The gold dredge is new only in its modern application to mining conditions, where placer and hydraulic mining for various reasons are not profitable or are handicapped by local legislation. Fifty years ago gold dredges of a very primitive type were used in California and New Zealand, and skeletons of their massive timbers may be found abandoned along river courses and in the plains; but these early ventures are so inferior to the modern electrical apparatus employed for this purpose, that gold dredging practically dates back only a few years.

The single-bucket or spoon dredge originated in New Zealand, and a powerful steam dredge of this type was in operation there in 1870, and ten years later the bucket and ladder dredge was introduced. The first steam chain bucket dredge was used in New Zealand a few years later, and by 1889 it proved so successful that upward of a score of them were built on a branch of the Molyneux River, at an average cost of \$17,500 each. From these early types of endless bucket chain dredges of New Zealand the modern mam-

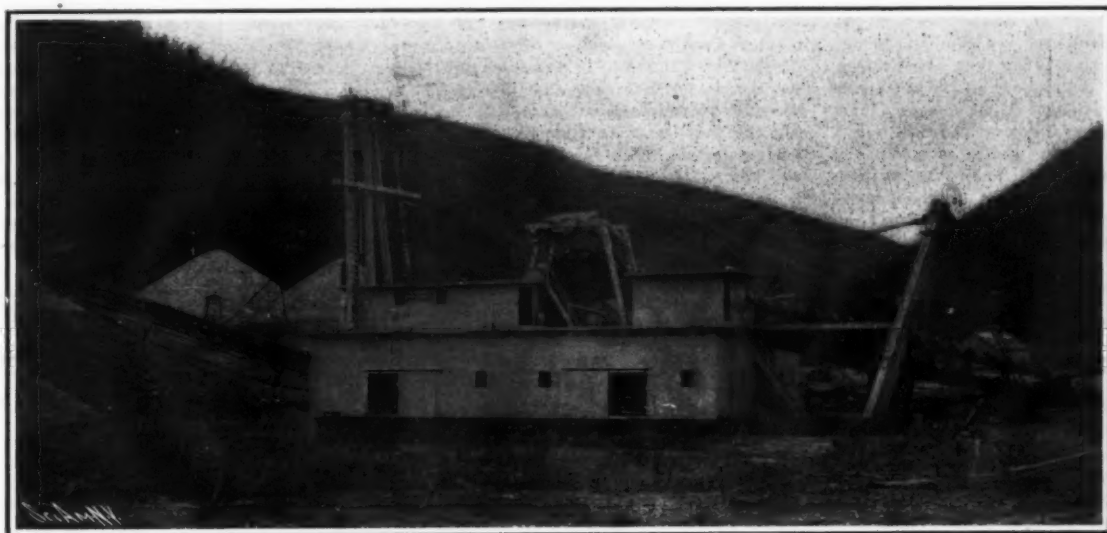
moth electrically-operated gold ships of California have been evolved. In 1902 there were nearly three hundred gold dredges in operation in New Zealand, and

the number was rapidly increasing, their operation being by steam, electric power, and current wheels.

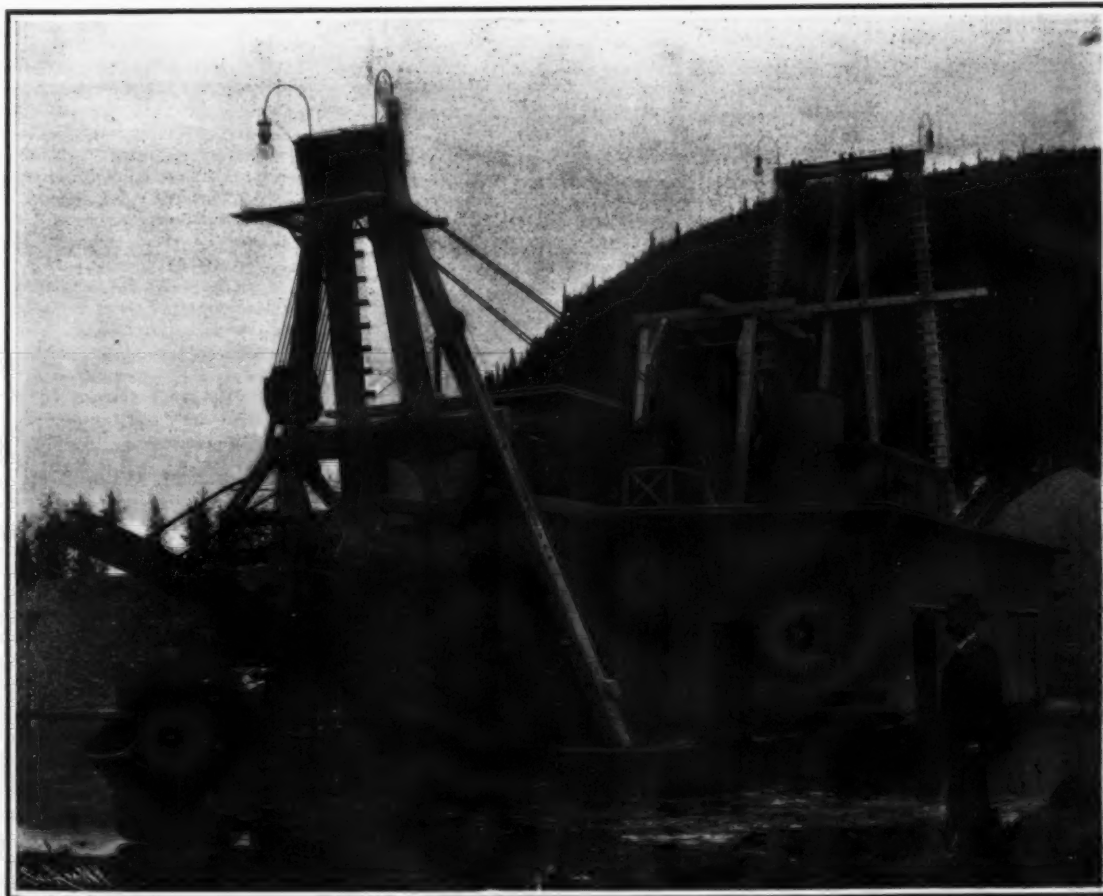
While a successful endless-chain bucket gold dredge was in operation at Grasshopper Creek in Montana in 1894, it was not until several years later that the present type of dredge was introduced and made successful. A New Zealand engineer who had been successful in operating dredges in that country had constructed a gold dredge on the Yuba River in 1897, and later the first successful gold dredge at Oroville, Cal. This latter dredge, while very primitive in type compared with the new ones, is still in operation, and its profits are sufficient to warrant repairs on it every year.

As a development the gold dredge has made sufficient headway in the past few years to make for itself a reputation second to no other mechanical invention for extracting gold from the earth.

It is freely predicted that our gold production will increase at a ratio scarcely conceivable a dozen years ago, simply through the building and multiplication of the gold dredge. Already the dredges in operation in this country are adding millions of dollars of gold to the world's supply. In 1902 the output of gold from the dredges in California alone amounted to \$867,665, and in 1903 this was



A MODERN GOLD DREDGE IN OPERATION.



A NEAR VIEW OF A GOLD DREDGE.

THE MODERN GOLD SHIP.

increased to \$1,475,749. In 1902 the number of dredges in operation scarcely exceeded a dozen and a half, and in 1903 there were upward of thirty-five gold ships. In 1905 there were forty dredges in operation in California, with half as many more in the course of construction.

Since the early part of 1903 the demand for these modern gold dredges has increased so rapidly that every machine shop building them has more orders than it can fill for some time to come. The demand is not only for home use, but for Alaska, South America, Europe, and Africa; but so far comparatively few have been shipped abroad. According to a manufacturing authority, the present rate of output of the gold dredges is about one machine a week; but owing to the extraordinary efforts being made to fill the orders, the various manufacturing plants will be able within a year or two to turn out one machine a day. So well satisfied are manufacturers that the gold dredge has come to stay, and that its use will continue for all time, that preparations are confidently being carried forward to turn out ten machines a day. This would mean such an enormous increase in the output of gold, that the supply might easily cause remarkable financial changes in the world's business.

The gold dredge is the most profitable and most efficient gold miner the world has ever seen. It represents the acme of scientific mining and inventive genius. It has almost reached perfection in the work of extracting ore from the earth and preparing it for the mint. So efficient and economical is it in its workings, that the dividends secured from the money invested range from ten to fifty per cent. It is apparently only a question of time before all the old placer and hydraulic mining regions that have been abandoned will be worked over again at great profit.

The continuous-chain bucket dredge is practically the only type that is being built, and scores of these are now in operation in the gravels of the Sacramento Valley districts, Montana, Idaho, Colorado, Oregon, Alaska, the Klondike, and New Zealand. While minor

details may differentiate one from another, they are practically similar in principle. Most of them are driven by electric motors, which have been so carefully adapted to the work that they save time and labor to a remarkable degree. The gold ship of to-day consists of a huge hull, with lines and spuds to hold it in position when in operation, and a digger, screen, sluice table, sluice boxes, stacker, pumps, amalgamator, and sand pump operated by separate electric motors. The size of the ships, buckets, and motors has steadily increased, and the output of the dredges has correspondingly advanced.

Owing to the cheapness of timber, most of the dredges of California have had their hulls constructed of wood, but steel hulls have more recently been introduced. A number of dredges with steel hulls have been in operation in Dutch Guiana for a year or two, but they are of rather small size and limited capacity. The hulls range from 30 to 50 feet beam to 80 to 130 feet in length. The size of the hulls is limited only by the size and capacity of the buckets, which determine the output and efficiency of the whole ship. Steel hulls give more rigidity and longer life, but with the tendency to increase the size and capacity of the dredges, designers are still uncertain as to the ultimate use of wood or steel. In California the hulls are usually built on the site of mining operations, and the motors and machinery shipped from the manufacturing plants to be assembled by engineers. In manufacturing steel hulls the attempt has been made to ship the different sections of the hull direct from the manufacturing plant and put them together where needed. As a gold dredge is not installed in any place until definite data has been secured to show that there is ore enough to work for years to come, there is little necessity of taking the hull apart to transport to another district. Sectional steel hulls for this reason may not have any very superior value over wooden affairs, especially as experience has shown that nearly all parts of the machinery have to be renewed during the ordinary lifetime of the wooden hull.

From three to five million dollars are invested in gold dredges and the shops for making and repairing them in California alone, and upward of 25,000 acres of rich land have been mapped out for dredging. The mining companies operating the gold ships have paid farmers upward of a million dollars for the land which they propose to work over. Much of this land was worthless for farming. From the Oroville and Folsome districts it is estimated that some \$60,000,000 of gold will be added to the wealth of the State by means of the gold dredges. In the Sacramento Valley districts it is estimated that with gold yielding 15 cents per cubic yard large profits can be obtained, and that within the next few years this will add some \$160,000,000 of gold to the world's supply.

A good deal of the land that is rich in gold cannot be worked successfully by the dredges, and large fortunes have been wasted in attempting to do the impossible. When the dredges were first brought to something like their present state of efficiency, a good many mining companies, reading of the profits of some of the dredge ships, invested in lands and equipments which proved their ruin. In many of these places the bedrock proved so hard to dig that the gold could not be lifted, and some of the drift mines in layers of gravel deposits were overcapped with such a hard lava deposit that the dredges could not be profitably worked. The most successful mining with gold dredges is in districts where the gravel has an excess of water and a soft bedrock. Wherever these conditions exist, and the amount of gold is found sufficient to warrant operations, the modern gold ship is found to be the most profitable invention yet designed for recovering the precious metal from the earth. Throughout the world there are millions of acres of such land, which dredges could profitably work for decades to come. The amount of gold is too slight for any other form of mining, and the gold ship practically has the field to itself, going over land which former miners have abandoned to scoop up the golden flakes to add to the world's supply of precious metal.

## AN AUTOMOBILE VACUUM CLEANING PLANT.

A SUBSTITUTE FOR THE AMERICAN HORSE-DRAWN TYPE.

BY THE SCIENTIFIC AMERICAN'S ENGLISH CORRESPONDENT.

An interesting gasoline motor-propelled vehicle and vacuum cleaner, the power for each of which functions is derived from the same engine, has recently been constructed for the Vacuum Cleaner Company, of London. For some time past this cleaning company has utilized a stationary gasoline motor for the

and 12-horse-power Wolseley horizontal engine fixed in the usual position on the chassis. The frame is of heavy channel steel in preference to pressed steel, which would have been too springy for the purpose. The wheel base is 8 feet 2 inches with a track of 4 feet 8 inches, which is 5 inches wider than ordinary,

ly at 800 revolutions per minute, at which speed the nominal horse-power is developed. The ignition is the electric high-tension system with accumulators and induction coils having vibrators. Compression relief cams are provided to facilitate the starting of the motor.

A special radiator of very large capacity is fitted, and this is kept cool when the pump is running by a fan driven from the engine, which enables the equipment to run for very long periods while the vehicle is stationary, without unduly heating the cooling water. An additional water tank of ample size is carried beneath the engine. The water is circulated by means of an eccentric rotary pump driven by the motor. This provision is essential, as the plant has to work stationary for several hours continuously, and as little assistance can be derived from the air for cooling, a more extensive water system than is usually adopted is required.

An oil reservoir is placed on the dashboard, and separate pipes with independent sight feeds lead to all important bearings.

The friction clutch, which is of the leather-faced cone type, is mounted on the crankshaft and transmits the engine power through a Renold silent chain to the gear box countershaft. Four speeds forward—and one reverse—are provided for the propulsion of the vehicle, the forward gears giving speeds of 5, 9, 14, and 19 miles per hour respectively with the engine running at normal speed. The drive to the road wheels is by means of side chains from sprockets on the ends of the differential shaft. The differential gear is of the spur gear type. All shafts run in ball bearings of the Wolseley pattern, but the road wheels are fitted with plain phosphor-bronze bearings. The countershaft is extended, and has mounted upon it a gear which drives another gear on a second countershaft above the gear box. This second countershaft has a sprocket upon it, from which a Renold silent chain drives a sprocket on the compressor shaft of the vacuum plant. Arrangements are made for throwing the second countershaft out of gear when not in use by moving the gear with a separate handle. To bring the compressor into gear the main friction clutch has to be disengaged, the gears intermeshed, and the propelling change-speed gear lever placed in the free, or neutral, position. Then, as the main clutch is re-engaged, the compressor starts up, and continues to run until the pedal operating the main clutch is thrown out.

Two independent systems of brakes are provided, the pedal operating cast-iron shoes, which expand



A COMBINED GASOLINE MOTOR-PROPELLED VACUUM CLEANER. THE ENGINE OF THE VEHICLE ALSO DRIVES THE VACUUM APPARATUS.

purpose of supplying the motive power to the vacuum cleaner, but transport has been provided by an independent source, either animal or steam. This system has severely handicapped the economical transport and operation of the plant in remote districts. To remedy this defect a special combination was designed by the Wolseley Motor Car Company, of Birmingham, in which the motor which propels the car is utilized as a stationary engine to drive the vacuum compressor.

Owing to the peculiar requirements of such a combined plant, the vehicle is of special construction, involving several modifications in the standard designs of the motor company though it is fitted with a stand-

to insure easy running and general rigidity. The front and back axles are specially strong, and the whole of the suspension has been given special attention, owing to the weight of the vehicle, which is about 3 tons in full running order with the vacuum cleaner plant and four men.

The equipment consists of six or eight lengths of hose, special tool boxes, and a large store of gasoline to enable the machine to be kept running all day if necessary. The wheels are of artillery pattern specially built, and are shod with solid tires all round, the back wheels being fitted with twin tires.

The 12-horse-power, two-cylinder, horizontal engine has a 4½-inch bore by 5-inch stroke, and runs normal-



into the inside of the drums cast on the sprockets of the road wheels, and the side hand lever operating brake bands on the outside of the same drums. The steering is of the Wolseley irreversible pattern, the worm and segment bolted direct to front axle.

A strong canopy is fitted for carrying the hose, and what other equipment is necessary for the vacuum plant. Two extra men are carried on a footboard provided at the back of the vehicle.

The muffler is placed underneath the canopy, and

its outlet emits the exhaust into the open air above the canopy. This obviates all danger of objectionable smell when the plant is standing in operation outside a private house. The whole of the mechanism is carefully protected from the dirt and dust of the road by a footboard below it.

The vacuum reservoir is carried beneath the back axle, and is built solidly into the frame, of which it forms the back member. The pump has been specially balanced, and with its flexible chain drive to the

engine, it runs in an extremely satisfactory manner.

There is undoubtedly a great future before this class of automobile combined plant. It will enable country houses to be reached rapidly and economically, and will insure that but little time is wasted in traveling from one order to execute another. It is of course demanding heavy work from the engine, but the horizontal Wolseley motor is specially adapted for hard, constant work, and will no doubt give a very good account of itself in this direction.

## AN ELECTROLYTIC RECTIFIER FOR AMATEURS.\*

HOW IT CAN BE MADE AT HOME.

BY FREDERICK E. WARD, E. E.

It is not generally known by amateurs and others who have occasion to use direct current for experimental work that such current can be easily and conveniently obtained from an alternating current by means of the aluminium cell electrolytic rectifier. Wherever a source of alternating current supply at low voltage is available, however, as it is in a large number of electrically lighted dwellings of to-day, such a rectifier can be used to great advantage to furnish direct current for operating almost any kind of apparatus that can be driven with primary batteries, as well as to charge small storage batteries.

The electrolytic rectifier in its simplest form consists of two plates, the one being of aluminium and the other of lead or some other inactive material, immersed in a glass jar filled with a solution of some salt in which aluminium is easily oxidized. As far as mechanical construction is concerned, such a cell closely resembles a primary battery, but when the cell is included in an alternating current circuit its action is analogous to that of a somewhat leaky check valve placed in a water pipe when the pressure applied to the water is alternately positive and negative. For when the electric current passes in at the lead plate and out at the aluminium plate very little resistance is offered by the cell, while when the current attempts to pass in the reverse direction it meets with great opposition, due to a thin film of non-conducting oxide which instantly forms on the surface of the aluminium. No practical results, however, can be obtained with the single simple cell just described, as it utilizes only one wave of each alternating-current cycle, and, by reason of its being a leaky "valve," it fails to entirely suppress the other wave. In its simplest practical form a rectifier consists of two electrolytic cells properly connected to a small autotransformer. With this combination there will be obtained a unidirectional pulsating current, at an efficiency as shown by watt meters placed in the alternating and the direct current circuits of about 60 per cent, or very considerably higher than can be obtained by the combination of a small induction motor driving a direct current dynamo.

The following description gives all the necessary information for making and using a small rectifier, the materials for which can be purchased for about three dollars. It is designed to run on a 100 to 120-volt, 60-cycle alternating current circuit, and to have a maximum capacity of five amperes. Any desired current up to this value may be taken from the direct current terminals, at any one of three different voltages having the approximate values of 7, 20, and 45 volts, by making the appropriate connections.

The autotransformer required is shown by the drawings in Fig. 1. It consists of a single coil of magnet wire wound on a rectangular wooden spool, inside of

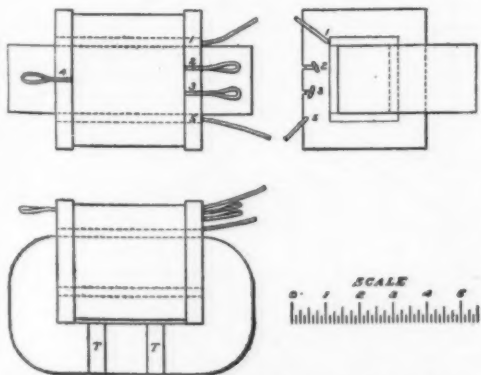


Fig. 1.—DETAILS OF AUTOTRANSFORMER.

which a bundle of steel strips are afterward placed to form a core. The spool may be made of any kind of wood, but well-seasoned white pine or whitewood is recommended, as these are free from liability to warp and at the same time cheap and easy to work. It is best to dry the wood in an oven before it is cut up.

For the body of the spool, four pieces 21-16 inches wide, 4 3/4 inches long, and not thicker than 1/4 inch are required. These should be securely glued and nailed together so as to form a rectangular tube 4 3/4 inches long and measuring 19-16 inches by 21-16 on the inside. For the heads, two pieces 1/2 inch thick, 3 3/4 inches wide, and 4 3/4 inches long are needed. Through the middle of each a hole about 21-16 inches

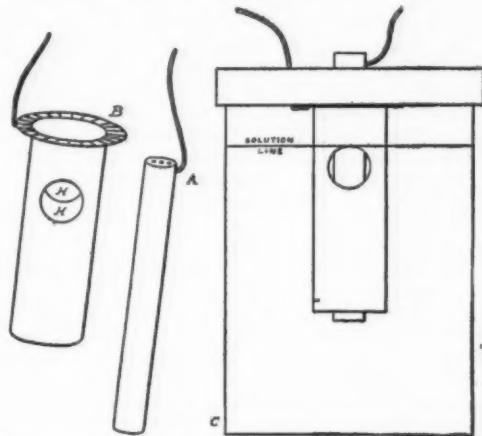


Fig. 2.—DETAILS OF ELECTROLYTIC CELLS.

A. Aluminium rod. B. Lead cylinder. C. Complete cell.

wide by 29-16 inches long should be cut to fit snugly over the ends of the tube. When the heads are securely glued to the central tube, and braced by a few wire nails driven into them from the inside, the whole will form a strong spool having a space 3 3/4 inches long between the heads for the winding. The corners of the tube where the wire is to be wound must be well rounded off with a file after the spool is finished, to avoid the difficulty of having to bend the wire around square corners. In one of the heads two small holes and two sawcuts must be made as shown at 1, 2, 3, and 5 in Fig. 1, while in the other head only one sawcut, 4, is needed. These holes and slots are for bringing out ends and loops in the winding, so that connections may be afterward made to different parts of the winding and the various direct-current voltages be thereby obtained. On the heads of the spool the numbers 1 to 5 should be plainly marked or carved so that they will not become obliterated.

The coil is to be wound of No. 14 double cotton covered magnet wire, of which nearly five pounds, all in one piece, will be required. This is to be wound on the spool in eight layers of about fifty turns each, as follows: First pass about 4 inches of one end of the wire out through the hole numbered 1, and then wind on four even layers like thread on a spool. The work can be done most easily by clamping the spool on the face plate of a lathe and turning it over slowly by hand as the winding progresses. It is well to give each layer a coat of shellac before winding the next. When the four layers have been put on, make a short loop in the wire at sawcut marked No. 2 and allow the loop to project outside an inch or so, as shown. Continue the winding as before until two more layers have been put on, and then bring out a second loop at sawcut No. 3. Next wind one more layer and leave a loop at sawcut No. 4, and finally finish by putting on the last, or eighth layer and passing the end of the wire out through hole No. 5. After the winding is complete it should be protected from possible injury by a covering of two or three layers of cloth fastened on with glue or shellac. If it is desired to make a particularly neat job of the autotransformer the heads may be made of hardwood, and the various wires and loops in the winding may be attached to five binding posts screwed on the heads; but, of course, the apparatus will operate just as well without them.

The core is to be made of strips of thin sheet steel cut two inches wide. This steel may be bought at almost any hardware store, in the shape of so-called "Russia iron," "stovepipe iron," or "roofing tin." One-

sixty-fourth inch is a desirable thickness, but anything less than 1-32 inch will answer, and it doesn't matter if the material is rusty. About twelve pounds will be needed for the core, in strips of different lengths varying all the way from 12 up to 22 inches long. Insert the strips into the hole through the spool one by one, putting in the longest ones first at the side nearest where the terminals are brought out and finishing up with the shorter pieces at the opposite side. Enough strips should be used to fill up the hole snugly. If the strips are rusty it will not be necessary to insulate them from each other, but if they are clean and bright, or tinned, it is a good plan to insert an occasional strip of paper so as to divide the core up into groups of half a dozen sheets each. Another way is to give every fifth strip a coat of shellac on both sides and let it dry for a few minutes. The strips must next be bent around one at a time, so that their ends meet at the side of the coil opposite the terminals. Trim off the ends of each strip with a pair of tinner's snips so that they meet without overlapping, forming what are known as "butt joints." Care should be taken that the successive joints do not come at the same place, but overlap each other about two inches as they pile up, in the same way as the joints in brickwork. After the ends are all in place, they may be held permanently by wrapping them with a layer of bare copper wire or by soldering bands of tin around them, as shown at T, Fig. 1. This completes the autotransformer.

For the electrolytic cells, two round glass battery jars 6 inches diameter by 8 inches deep are best, but as the shape of the vessel is not important any other glass jar of equal capacity and depth may be used. Make two wooden covers about 3/4 inch thick to fit over the tops of the jars, and bore a 3/4-inch hole straight and true through the center of each. To thoroughly insulate them and render them waterproof they should be first dried in an oven, next immersed in a pan of melted paraffine and boiled for a few minutes, and then set aside to cool in the paraffine. When nearly cold they will be ready to be taken out and wiped off.

For the central electrodes, two round aluminium rods 3/4 inch diameter and 6 1/2 inches long are required.

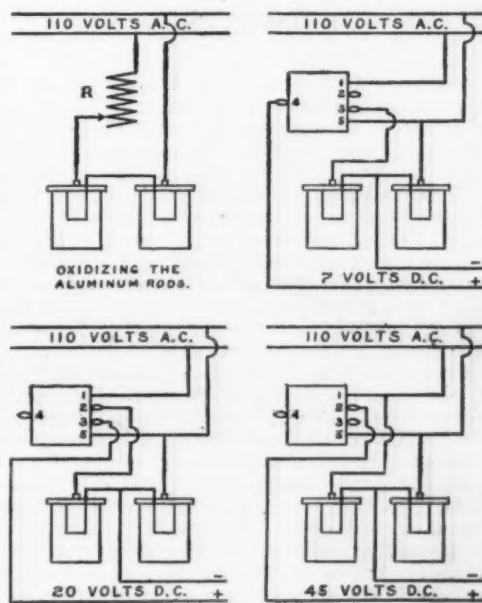


Fig. 3.—DIAGRAMS OF CONNECTIONS.

These must be of commercially pure aluminium, and not the so-called "hard stock" or alloy. Fasten to one end of each rod a piece of No. 14 copper wire to serve as a terminal. One way to do this is to drill a small hole through each rod near one end, and then insert the wires and drive down the aluminium until the wire is tightly pinched. See Fig. 2 A. A better finish can, of course, be made by tapping out holes in the

\* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

rods and putting on binding posts or thumbscrews, but do not try to solder anything to the aluminium, as it is very difficult to do this satisfactorily.

The lead electrodes are best made up in the form of cylinders suspended from the wood covers and surrounding the aluminium rods, as shown at C in Fig. 2. For these, two pieces of sheet lead  $5\frac{1}{2}$  inches square are required. It should not be less than  $3\frac{3}{32}$  inch thick, as the metal is slowly corroded away in use. Bend the pieces around a cylinder of wood such as a curtain pole, and form into cylinders  $5\frac{1}{2}$  inches long by  $1\frac{1}{4}$  inches diameter. A few drops of solder should be used to hold the seams together, or the cylinders will unroll as soon as they are put in service, due to the expansion of the inside surface when it becomes oxidized in action. Make slits  $\frac{1}{2}$  inch deep all around one end of each cylinder and bend out the metal so as to form a collar, as shown at B in Fig. 2, by means of which the electrodes may be fastened to the under sides of the wood covers with a few small brass screws. On the opposite sides of each electrode cut a one-inch hole as shown at H, H, Fig. 2, having its center  $3\frac{1}{2}$  inches from the bottom. These holes are very important, for reasons that will appear later on. A foot of No. 14 copper wire should be soldered to the collar of each cylinder, and passed up through a small hole bored in the cover, to serve as a terminal. When the aluminium rods are inserted in the  $\frac{3}{4}$ -inch holes previously bored in the covers to receive them, they should hang down in the centers of their respective cylinders. If there seems to be any possible danger of a rod touching its cylinder anywhere, it should be firmly "braced up" with a few wood toothpicks wedged around the rod where it passes through the cover; for if the lead and the aluminium come in contact with each other while the rectifier is in operation it will make a dead short circuit on the alternating current line.

To make up the liquid for the cells, put one pound of crystallized sodium orthophosphate in the bottom of each jar, and fill up the jars with lukewarm (not hot) water to about an inch from the top. Stir with a stick until the salt is dissolved, and put on the covers with their elements attached. When thus assembled, the cells will appear as shown at C, Fig. 2, much resembling that type of bell battery in which the zinc rod hangs within a carbon cylinder.

There will be only one thing lacking now that must be supplied before the apparatus can be set at work, and that is a coating of oxide on the aluminium rods. This has to be formed by the alternating current itself, for which purpose the cells may be temporarily connected to the 110-volt power mains as shown in the first diagram in Fig. 3. A resistance, R, of about ten or fifteen ohms must be used to prevent the cells from taking too much current at first. After half a minute this resistance may be gradually reduced to nothing, and the operation will be complete.

For actual service, the autotransformer and cells are to be connected up as shown in one of the three other diagrams in Fig. 3. The only difference between these lies in the connection of two of the wires, the position of which determines the voltage available at the direct-current terminals. The autotransformer may be connected to a 110-volt lamp socket by means of a sufficient length of No. 16 lamp cord and an attachment plug. A fuse having a capacity of three or four amperes should be included in this circuit, as an accidental short circuit on the direct current line is also a short circuit for the alternating current. As a matter of convenience, some form of variable resistance ought to be provided in the direct current circuit for the purpose of adjusting the current to any desired value.

The aluminium rods and the liquid in the jars are the parts that wear out most rapidly in use. The rods last a long time, but become gradually eaten away and should be renewed when they become as thin as a lead pencil. Their useful life and efficiency can be increased by occasionally renewing the oxide on them by putting them through the same process as was done for that purpose the first time, especially when it is desired to start up the apparatus after a period of idleness. There is also some economy in raising up the rods so that they do not dip so deeply in the liquid when it is desired to use very small currents for long periods.

The liquid in the jars becomes gradually decomposed by use until it reaches a stage where it can no longer serve its purpose. When this point is reached the "electrolytic valves" will no longer be able to close against the alternating current, which results in the apparatus drawing an excessive current from the line and blowing its fuse. If the rectifier is feeding five amperes into the direct current circuit, the useful life of the liquid will be about twenty hours, while if only one ampere is being used it will last about one hundred hours. Where the apparatus is to be used only occasionally, and for short periods of time, the simplest way to renew the liquid is, obviously, to throw it away and make up a fresh supply. If, however, it is desired to keep the apparatus in operation continuously for long periods of time, it may be done as follows: Procure half an ounce of blue litmus, powder it up with a spoon in a teacup, add a little hot water, and stir until as much as possible is dissolved. Put half of the mixture, sediment and all, into each electrolytic cell, thereby dyeing the liquid a pale blue. Keep on hand a supply of strong phosphoric acid, and add a little of it to the cells from time to time as required. Pour in the acid slowly and stir with a stick. When a sufficient quantity has been put in, it will be indicated by the dye in the liquid changing in color from blue to pink. Do not add an excess of acid. If the apparatus is doing heavy work it should be thus supplied with acid about every twelve hours, while if

it is not being used to furnish more than one ampere it will not need to be thus renewed oftener than every other day.

Even this last process of rejuvenation, however, will not make the cells work indefinitely. The end comes when the waste products, which fall down to the bottom of the jar, rise to a sufficient height to close up the bottoms of the lead cylinders and interfere with the circulation of the liquid. When this happens the liquid must be thrown away to get rid of the sediment, though most of the litmus can be saved by pouring off the clear liquid at the tops of the jars and mixing it with the new solution. The free circulation of the electrolyte between the aluminium rod and its lead cylinder is absolutely necessary to the proper operation of the apparatus. For this reason the solution level in the jars must always be kept up to the tops of the round holes in the lead electrodes, thus permitting the electrolyte around the aluminium rods to rise and flow outward as fast as it becomes heated by the passage of the current.

When made and operated in accordance with the above instructions an electrolytic rectifier will give very great satisfaction. It will displace about twenty-five powerful bichromate batteries, and can be cared for with very little time, trouble or expense. The current that it delivers is unidirectional, but pulsating. That is, it flows always in the same direction but varies in strength from zero to a maximum value and back to zero 120 times each second, being very much like the current delivered by the old Siemens H armature dynamo fitted with a two-part commutator. These tiny pulsations follow each other with such rapidity that the current gives, for most purposes, just the same results as a battery current, and it is only in a few isolated cases that any objection can be urged against a rectifier. For certain particular purposes, however, such as experiments in telephony or wireless telegraphy and occasionally in the running of a small motor, an annoying hum is set up by the pulsation. When this occurs, an almost obvious remedy is to run the apparatus with storage batteries and afterward recharge the batteries with the rectifier. To do this, however, requires batteries of too great size and value to be within the reach of many amateurs, but if the charging and discharging be carried on at the same time an almost ridiculously small battery may be used. Simply connect in parallel with the rectifier a sufficient number of storage cells to give the required voltage, and feed the apparatus from the combination. When used in this way the storage cells serve to reduce the fluctuations in voltage by giving out energy at the moments when the rectifier voltage is passing through zero and recharging when the latter is above its effective value. Used in this way, a series of good "test tube size" storage cells, or even a set of dry batteries, will smooth out the pulsations sufficiently well for nearly all cases that may arise.

## VARNISH FOR WICKER WORK.

### SOME PRACTICAL SUGGESTIONS ON A MISUNDERSTOOD SUBJECT.

In spite of the high importance to which the wicker work industry has attained, it remains, as regards the varnishing, or properly speaking, the varnish used, behind the times, according to the *Farben Zeitung*. With peculiar preference, turpentine oil varnishes, especially dammar and rosin varnishes, are still used for the varnishing of wickerware, and in more recent times, cheap turpentine oil enamel paints, which are neither appropriate to the material nor suitable as regards drying, as well as strength and durability under wear. Every basket-maker knows that dammar and rosin varnishes stick, and it is further known that on green wood, as which we must class the willow twigs, they dry even more imperfectly, and become less hard than on a painted surface or any other non-absorptive surface. The moisture, inseparable from basket material, plays no unimportant part in these conditions. How unpleasant it is when baskets, in daily use, become sticky under the heat of the hand, or when the varnish on wicker furniture, like settees, reclining chairs, etc., softens under the effect of the bodily heat of those using them and possibly even soils the clothing, aside from the fact that the varnish itself becomes dull and without brightness and that fibers from the clothing remain sticking to it. These evils can only be remedied if the basket work manufacturers will decide to use spirit varnishes and varnish paints exclusively for the finishing of their work and wholly exclude turpentine-oil varnishes from employment. Spirit varnishes possess the great advantage of drying quickly and—if they are not mere solutions of rosin—of rapidly hardening; they do not soften under the heat of the hand and—a qualification that cannot be underestimated—they do not smell; when dry the odor is gone, whereas in the case of turpentine-oil varnishes

—the best turpentine oil is not always used—it often hangs about for days. They are at the same time equally durable, will not crack or split and do not peel off. The objection that spirit varnishes, on damp basket work, turn white, is no good reason for not using them; the white "bloom" is gone in a short time and, moreover, the wicker work can easily be superficially dried by heating. It would, therefore, be to the interest of the varnish manufacturing industry to encourage the use of spirit varnishes in wicker work factories, which can be accomplished by bringing to their attention the faults of turpentine-oil varnishes as well as dammar and rosin varnishes, and impressing on them the merits of the spirit varnishes.

As varnishes for wicker work, the following recipes will be found adapted:

**Colorless.**—10 parts by weight of spirit-soluble Manila copal, white fragments, 3 parts of galipot or thick turpentine, and 17 to 20 parts of alcohol.

**Yellowish.**—The same as above, except that in place of Manila copal, white fragments, ordinary spirit-soluble kinds may be used.

**Brown.**—10 parts by weight of spirit-soluble Manila copal, 3 parts by weight of galipot or thick turpentine, 17 to 20 parts by weight of alcohol. Colored with Bismarck brown (2 to 3 per cent) until the desired depth of shade is obtained. To this brown varnish can also be added black tar dye stuff, which does not react with the Bismarck brown, until the darkest shades are obtained.

**Black.**—Same as the foregoing, colored with 1 to 2 per cent of black tar dye stuff. A good covering, deep-black varnish, is obtained by rubbing down  $\frac{1}{2}$  part by weight of lamp black and 10 parts, by weight, of the "yellowish" varnish.

Green, red, blue, yellow, etc., varnishes are prepared by mixing from 1 to 3 per cent—according to the color strength—of the desired tar color substance with "colorless" or "yellowish" varnish.

**Red Brown.**—10 parts by weight of red Acaroid rosin, 3 parts of galipot or thick turpentine, spirits in quantity according to the purity of the Acaroid rosin.

In accordance with the prevailing taste of the times, much of the basket work is coated with enamel colors and it is especially the so-called broken color tones (pale yellow, pale gray, pale green) also glaring colors like dark red (vermilion or cherry red) and green, are very popular. Oil paints require altogether too much time for drying. Turpentine-oil enamel colors, on account of their low cost in the inferior qualities, are bought, must be applied thick and require too long to harden, apart from the fact that at comparatively low temperature they soften again. Here, too, spirit-enamel colors may be used to advantage. As a rule, they are produced for the broken shades, for instance, by mixing lithopone in the proportion of 10 to 10, with the "colorless" or "yellowish" basketware varnish and adding chrome green, ultramarine blue, etc., ground in varnish in small quantities, until the desired shade is obtained. In mixing, it must not be forgotten that the colors when dry are considerably darker than in their fluid condition. It must be noted that of all variegated colors, only chemically pure qualities should be used; in imitation vermillions, for instance, which are produced according to very different methods, it often happens that in mixing them with the varnishes described previously, they will become at once, or in a short time, granulous or quite hard, and consequently useless; vermillion imitations should therefore first be tested as to their composition.



# SOLDERING AND SOLDERING PROCESSES.\*

## THE FORM OF SOLDERS.

SOLDERS are used in different forms, which depend upon the degree of fusibility, and also upon the presence or absence of valuable metals, such as gold, silver, or aluminium in the solder. If it is composed of cheap materials, the principal point is to make a firm soldering, without much regard to the amount used; but if precious metals are contained in it, waste must be avoided, and in this case it is shaped into certain definite forms.

The shaping of soft solders has been described in a previous article; they are poured out into iron molds, or sometimes simply ladled out upon a piece of sheet metal, whereby strips of different thickness are formed. But although soft solder is cheap the amount of material saved by having it in a suitable form would be a considerable item in large workshops, where a great deal is used. It can be cast in bars or rods of varying thickness and size, and the larger, heavier bars used for coarser soldering operations, while in soldering small and delicate articles it is easy, with slender sticks of solder, to use no more than is absolutely necessary to hold the parts together.

The solders which contain precious metals are usually cut into thin strips, and this is also done in the case of common solders, for very delicate work. The former are mostly ductile enough to be stretched between rollers or drawn out into wire. In this case they are cast in cylindrical rods, which are then drawn out into wire and flattened between polished rollers, coming out in the form of very delicate strips. These are cut with scissors into the desired length. For casting the cylindrical rods, the best molds are of iron or bronze, consisting of two plates, each of which has a number of semicircular grooves exactly fitting together. These are joined into one where the metal is poured in, dividing afterward.

Before casting the rods, which are from 3 to 5 millimeters in diameter and from 10 to 15 centimeters long, the mold is taken apart, and the grooves are rubbed with oil, to prevent the adhesion of the solder. The two parts are then screwed firmly together, and the metal is poured in slowly. As soon as one groove is filled the mixture is carried into the next, and twenty or thirty rods can be cast in a few seconds. When all grooves are full the mold is dipped in water, opened, the rods thrown out, and the mold made ready for another casting. The irregular pieces left on the ends of the rods where the metal is poured into the mold are removed with sharp pincers, and melted over again.

If the solder is desired in the form of fine filings, as is sometimes the case for very delicate work, the simplest way to produce these is to put the rod of solder in a turning lathe and hold a file against it while rapidly revolving, letting the filings fall into pasteboard boxes underneath. The task again of pulverizing brittle solders is a very easy one. Most of these contain zinc, and this metal, alone or alloyed, has the peculiar characteristic of becoming ductile at a certain temperature (120 deg. to 130 deg. C.), while if heated above 200 deg. C. it becomes so brittle that it can easily be reduced to powder in a mortar. By means of this characteristic, hard solders, such as German silver solder, are easily made into powder. The mortar is heated strongly, put into hot sand, and thin sheets of the alloy, still very hot, thrown into it, when they can be pulverized without any difficulty.

**Granulation of Solders.**—A very suitable form for hard solders is that of fine granules. These are produced in different ways. The most common method is to pour the melted solder in a thin stream into a large shallow vessel filled with water, stirring constantly with a birch broom. The stream of metal as it falls is divided into many little drops, which quickly harden and collect at the bottom of the vessel. Another method is to place a cannon ball in the center of a very broad and shallow vessel of water, so that half of it is above the water. The hot metallic mixture is ladled out over the ball, becomes spray as it strikes it, and the drops fall into the water.

These methods are very simple and easily carried out, but give decidedly imperfect results. The granules vary considerably in size, and many of them are not even spherical in shape, but long. To obtain any kind of uniformity, they must be sorted out by means of sieves. These have meshes of different sizes, and are placed one above the other, the one with the coarsest meshes at the top. The finest granules fall through the lowest sieve, and on the upper one are left the large, irregular ones, which must be melted over again.

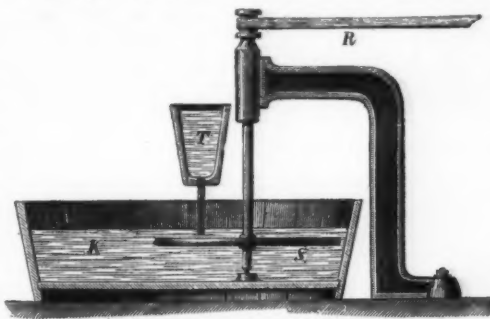
For granulating large quantities of solder, a process is employed, which resembles the casting of shot. A metallic sieve, with very small openings, is placed as high as possible above the floor, 10 or 12 meters at

least, and filled with small pieces of red-hot coal. On the floor beneath it is a tub of water to receive the drops of the metal, which is poured over the coals in the sieve in a thin stream. It trickles through these, and comes out from the sieve in drops whose diameter is determined by the size of the meshes. In falling through the air the drops cool into perfectly round globules, which harden in the water, and the subsequent work of sorting them takes very little time.

If a stream of water of some force is at command, it can be utilized in the process of granulation. The water pipe is provided with a horizontal outlet, which can be closed by a cock, and which opens above a large reservoir for the water and the granules of the metal. The latter fall through a very small pipe, about the diameter of a large knitting needle, directly above the outlet of the water. The simplest way to arrange this is to bore a hole in the bottom of a small graphite crucible, and cement the small pipe into it. While one workman turns on the water, another pours the melted solder into the crucible; it strikes the stream of water at right angles, and is divided into very small drops, which fall into the reservoir.

To granulate large quantities of solder very quickly and evenly, the apparatus illustrated is to be recommended. This consists essentially of a metallic disk *S*, which can be rapidly revolved by means of the belt *R*, placed over a wheel of greater diameter. The disk *S* moves in the tub *K*, filled with water to from 1 to 2 centimeters above the upper surface of the disk. When this is set in motion, and the crucible *T* is filled with the melted solder, the latter falls upon the disk, and the centrifugal force granulates it and throws the globules against the side of the tub. The smaller the tube through which the metal falls, and the more rapid the rotation of the disk, the smaller will be these globules.

Whatever the method of granulation followed, there must always be a subsequent sorting by means of sieves, since grains of different size will melt more or less quickly, and it is important for successful



THE GRANULATING DEVICE.

soldering that they should be as nearly as possible of the same diameter.

### THE PROCESS OF SOLDERING.

The processes of soldering vary considerably according to the nature of the solder used, etc.; the method best suited to any particular case must be determined by the properties of the solder and of the metals to be soldered, and also by the size of the object. To solder cold metals with soft solder, the surfaces are first made clean and bright with some caustic agent; a little of the solder is then melted off with a heated piece of metal, the soldering iron, so called, and applied to the surfaces to be joined. But in the case of hard solder, not readily fusible, this process of cold soldering is insufficient; the surfaces to be soldered must be so strongly heated that the solder, when placed between them, will become fluid, and the whole be perfectly coherent. The required degree of heat is obtained in manifold ways, for small, delicate articles, especially gold and jewelry, the flame produced by the aid of the soldering pipe is employed; for larger objects soldering lamps of different construction. In the case of quite large objects, the heating and soldering are done directly over red-hot coals, or arrangements of bellows are employed by which certain parts of the object can be very strongly heated.

Since the general introduction of illuminating gas, the processes of soldering have acquired a new status; every large factory uses gas, by means of which a very high temperature can be obtained with little trouble or expense. In some rare cases soldering is done with the aid of oxyhydrogen gas, which gives the hottest flame known.

**The Soldering Iron.**—The most important accessories of soft soldering are the soldering iron or soldering bit, so called, and the soldering furnace or stove for producing the necessary heat. The soldering bit commonly used consists of a piece of pure copper, fastened

to an iron rod, with a wooden handle. The copper should be dense and heavily hammered; porous pieces are entirely unfit for soldering tools. The form and size of the soldering iron depends, of course, upon the kind of work, and there are many varieties. It should be as massive as possible for convenience, since it will hold the heat better, and will not wear out so quickly. Some soldering irons are pointed, in the shape of a four-sided prism, with a superimposed four-sided pyramid; others have the shape of a hammer. With the pointed tool the soldering starts from one point; with the hammer-shaped iron a line of soldering is concerned.

The process is as follows: The soldering iron, which must be clean and smooth, is pressed into the solder and turned around to make some of the solder adhere to it, which is then rubbed off on the metal, also clean and bright; or the tool, with the link of solder, is passed along over the seams and the drops evenly divided with the tool.

In order to avoid changing from one soldering tool to another, various modifications have been devised, which, however, have not found much favor. The simplest construction, on the whole, seems the best. A very good idea is to have the soldering iron fixed into a suitably shaped piece of iron; thus one handle will serve for several tools. The main point of this arrangement is that on the iron stem of the soldering tool is fastened a square piece of iron, which has at the front a square hollow; the actual soldering tool is a piece of copper which has a square projection on the back, corresponding to the hollow in the iron. When this is heated red hot in the soldering furnace, and inserted in the iron, the latter becomes hot, expands, and holds the piece of copper fast. On cooling, it can be easily removed with tongs, and another substituted.

Soldering tools have been constructed with a space inside, to contain melted solder, which runs out to the point of the tool through a groove, when a valve is opened by pressing a spring. The idea is to avoid the necessity of frequently renewing the solder, and is a very ingenious one; unfortunately, there are many difficulties in its practical application, the most serious of which is that the mechanism easily gets out of order from the continued heating of the tool, and the solder comes out too fast when this is moved quickly and the valve thereby opened too far.

The proper treatment of the soldering iron in the fire and during the soldering is a matter of great importance to metal workers. With suitable care one will last a long time in perfect condition, but carelessness will ruin it in a few days. The part actually used in the soldering should be kept tinned, as otherwise the copper will be oxidized by the constant heating, and soon wear out. Experience has shown that the simplest way is to tin the whole tool, and this is most easily done as follows: File and emery-paper the whole surface, to make it smooth as possible, then heat it to a point where a rod of tin, touched to it, will melt; dip it quickly into powdered rosin or into grease, which is better, and rub it over with a rod of tin. The tin will adhere, and it is well to have the coating as thick as possible, to protect the surface well. At the point of the iron the tin will soonest change to tin ashes, and it is customary to touch it to a piece of sal-ammoniac to remove this before putting it again into the solder.

The fuel used in the soldering furnace is also of importance in point of the preservation of the soldering iron. Formerly charcoal was almost exclusively employed, and this is a very suitable material, whose only disadvantage is its expensiveness. Attempts have been made to supersede it by anthracite coal, and this is, under certain circumstances, a very good fuel, yielding a great deal of heat. But care must be taken to obtain coal which is entirely free from iron pyrites. Coal which shows bright colors or golden specks (little crystals of iron pyrites) is absolutely unsuitable for the purpose. Iron pyrites, in the combustion of the coal, yields sulphurous acid, a gas which, on contact with the copper and the red-hot coal, is decomposed, and copper sulphate results. This is a compound which easily melts, and the soldering irons, if heated over this kind of coal, are quickly spoiled; besides this, there is the necessity for constant filing and retinning.

Coke, procurable from every gas factory, is perhaps, when well desulphured, so that there remains no odor of sulphur in burning, the best and cheapest material for soldering furnaces; it gives out a great deal of heat, and burns slowly. The consumption can be decreased by using furnaces of special construction, if only a few tools are to be heated.—Translated from the German of Edmund Schlosser's "Das Löten und die Bearbeitung der Metalle."

\* See also SCIENTIFIC AMERICAN SUPPLEMENTS 1610, 1626, 1636.

# THE NILE-RED SEA RAILROAD.

THE BUILDING OF A \$7,000,000 LINE THROUGH A WATERLESS LAND.

BY HAROLD J. SHEPSTONE.

ALTHOUGH it cannot be described as a particularly wonderful engineering feat, the Nile-Red Sea Railroad, which was formally opened by Lord Cromer on January 29, 1906, is nevertheless a piece of railroad work deserving of notice. True, it cannot be likened to the Trans-Siberian Railroad for length, or to the Simplon Tunnel line for engineering difficulties. Yet its erection demanded not only technical skill, but considerable tact

Port Sudan. The line has a total length of about 330 miles, and for the most part traverses a desert waste.

Leaving Port Sudan, the route followed is via Khor Okwat, Khor Adit, Khor Baramay, Khor Arab, and Khor Hundl. The highest point on the line is near Sinkat, 89 miles by rail from Port Sudan, where the road rises to 3,020 feet above the sea. The steepest gradient between Port Sudan and Sinkat is 1 in 100,

spans 110 feet in the clear and thirty-nine spans 55 feet in the clear. Besides these there are ninety-five 15-foot openings and one hundred and sixty 5-foot openings crossed by steel girders on small masonry piers.

It was the original intention to build the line from both termini until it met in the desert. A certain amount of material was accordingly accumulated at Atbara for this purpose. This was duly laid, but it



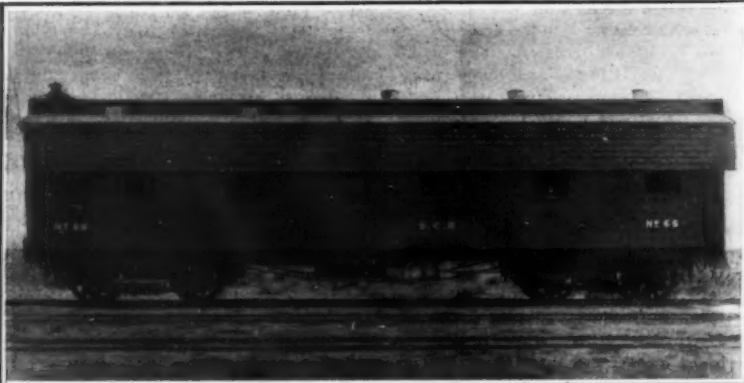
ROCK CUTTING IN KHOR KAMOBANA.



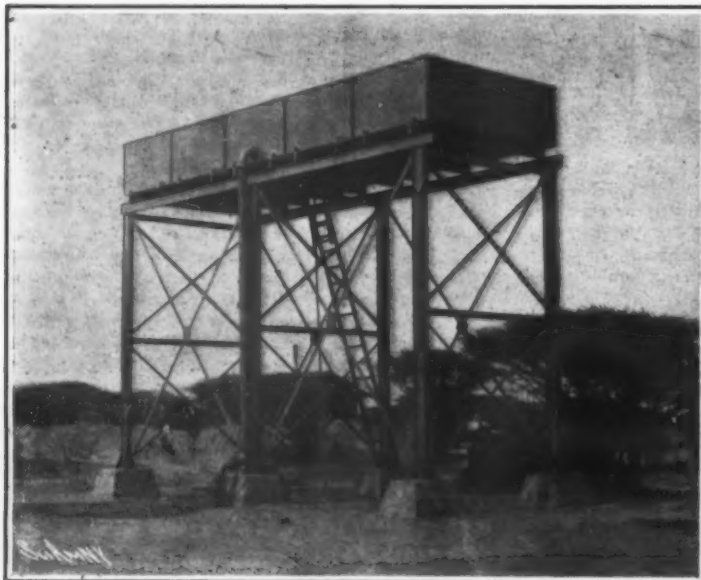
BRIDGE OVER KHOR OKWAT IN COURSE OF CONSTRUCTION.



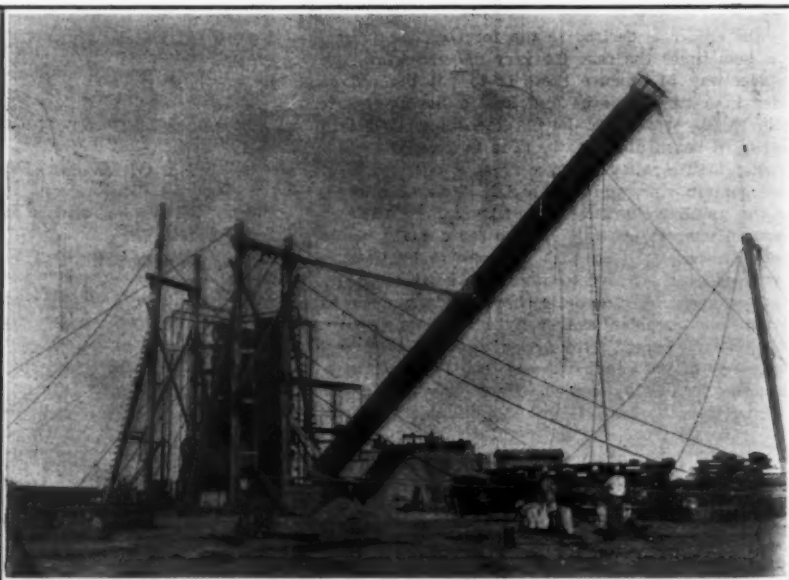
TYPE OF ENGINE USED BETWEEN PORT SUDAN AND THE SUMMIT OF THE LINE.



THE INSPECTION CAR.



TANK PEDESTAL.



ERECTING THE CHIMNEY OF THE WATER DISTILLING PLANT.

## THE NILE-RED SEA RAILROAD.

on the part of the surveyors and builders, who had many difficulties to surmount.

The principal object of this latest African railroad enterprise was to connect the existing Egyptian and Sudanese railroads with the Red Sea. It is invariably referred to as the Berber and Suakin line, but this is hardly correct. The railroad does not start from Berber, but from the mouth of the river Atbara, which is about twenty miles south of Berber. It then runs right across the Nubian desert to Port Sudan on the Red Sea, the latter place being some thirty miles north of Suakin. Port Sudan was chosen as the terminus of the route on account of its superiority to Suakin as a harbor. The engineers, however, used Suakin during the construction of the line as a base, and they are now busy building sheds and quays at

and between Sinkat and Atbara 1 in 125, while the sharpest curve has a radius of 995 feet. Throughout its entire course it is a single line railroad, boasting of a 3 foot 6 inch gage. The rails employed are flat-bottomed, 75 pounds to the yard between Port Sudan and Sinkat, and 50 pounds to the yard between Sinkat and Atbara. The sleepers are of Jarrah wood for fifty miles from Port Sudan, but beyond that they are of steel. One flat and one single fishplate were used. The rails are fastened to the wooden sleepers by spikes without bearing plates, and to the steel sleepers by keys. The points are bolt-locked and interlocked with signals. The heaviest part of the earthwork is in the section between Port Sudan and Sinkat, on which section also most of the bridges are found. These are all "through" bridges, and there are in all forty-two

was found too expensive to continue the line far into the desert. The want of water along this route, and the greater cost of transportation up the river as compared with that by sea to Suakin, prevented more being done from the Atbara end. So far as water was concerned, the builders at both ends had much to contend with. It had to be conveyed right from the bases to the working parties, and most of that required for the locomotives and bridges had to be obtained by distilling sea water, which was carried up the line in special tank wagons. Then it was some time before suitable coolies could be found. For six months the engineers tried the nomad Arabs of the Suakin hills, but they had to be replaced. They were found of little use for making earthworks or cuttings. In the end a large force of Sudanese laborers were imported, who for the



most part had worked on the Egyptian and Sudanese railroads.

A start was made at Suakin in August, 1904, but owing to the unsatisfactory labor of the nomad Arabs, very little progress was made for two months. Work, however, was begun in earnest in October, 1904, and in the following October the whole of the rails with the exception of those that crossed the bridges were laid. For months the line was laid at the rate of 1,500 yards a day. Indeed, in the comparatively short space of fourteen months the railroad across the Nubian desert extending over a distance of three hundred miles had become an accomplished fact. The line was, in fact, formally opened for traffic some two months before the expected time.

The rolling stock of the Nile-Red Sea Railroad consists of twelve locomotives, "heavy" type, for use between Port Sudan and Sinkat; fifteen locomotives, "light" type, for use between Sinkat and Atbara; three shunting engines; ninety covered wagons, 25 tons capacity; sixty-eight high-side wagons, all steel, 25 tons capacity; eighteen brake vans, twelve cattle wagons, six saloons, six inspection cars, etc. The above are all double-bogie wagons. Two steam locomotive cranes, 10 tons; one hand breakdown crane, 15 tons; twelve wagons, 5 tons capacity, four-wheel; and six cattle wagons, four-wheel. All the stock is fitted with the automatic vacuum brake.

The line was erected at the expense of the Egyptian government, and represents an outlay of about \$7,000,000. In a lengthy and appropriate speech at Port Su-

akin being the craters of extinct volcanoes. These craters have now become thickly covered with bamboos growing in wild profusion, and among these canes

but failed to penetrate to the homes of these people at the summits, though several members of the tribe were encountered from time to time. The people are of a



GANGS OF LABORERS AT WORK.

they found a race of pigmies who have their homes in these craters, surrounded by the dense undergrowth, and depending for their existence on raids upon the

very diminutive stature, and in view of the fact that the country is some distance from the Congo, it is surmised that they do not belong to the Congoese pigmies, but are probably a new race of people. The lower slopes of the mountains were found to be thickly populated by a race having splendid physique and very industrious, living principally on milk and honey, and devoted mainly to the raising of cattle. Food is plentiful, and altogether it proves a highly profitable field for the depredations of the marauding pigmies living among the heights above. The natives are evidently skillful apiarists, for in one village the explorers counted no less than three hundred beehives deftly fashioned in dugout tree trunks.

#### THE JOURNAL OF THE DISASTROUS GEORGE EXPEDITION.

It is stated that the South Australian government intend to publish the official journal of the disastrous George expedition, which set out from Oodnadatta in September, 1905, and the surviving members of which reached Adelaide last October after their adventurous journey in the unknown northern part of the Australasian continent. The story of this expedition will constitute one of the most thrilling and fascinating chapters in the annals of Australian exploration. The main object of this expedition was to prospect the portion of the northern territory between the Petermann range, which lies southwest of Lake Amadeus, the Tanami auriferous country in the north, and the West Australian boundary on the west. The party, comprising seven persons accompanied by twenty-one camels, followed the railroad to its head at Oodnadatta, and then set out in a northwesterly direction to the Opparina water hole. It was during one night early in December that the first mishap befell the little party during an attack made on their camp by the natives, in the course of which two members were struck down severely wounded by spear thrusts. This accident entailed a delay of fifteen days, and then an attempt was made to cross the terrible arid desert to



THE COURSE OF THE NILE-RED SEA RAILROAD.

dan on the last Saturday of January, Lord Cromer, in the name of King Edward VII. and his Highness the Khedive of Egypt, declared the railroad open to traffic. He also dwelt on the important part such a railroad would no doubt play in the opening of the Sudan. "The serious development of the Sudan commences from to-day," he said, "as the distance from Khartoum to the sea has been shortened by some 900 miles." There is no doubt that the Atbara and Port Sudan line will form the main artery of communication with the Sudan. From Atbara to Alexandria is 1,200 miles, which, of course, can be accomplished by rail and steamer. But to carry freight over this route is naturally much more expensive than to run it down to the Red Sea and there send it by coasting vessel to Alexandria. Then the railroad possesses great strategic importance. By its means the British and Egyptian governments could quickly put a large force of troops into the heart of the Sudan should occasion ever demand it. In a word, the Nile-Red Sea Railroad is the latest example of the white man's grip upon the dark continent.

#### A NEW RACE OF AFRICAN PIGMIES.

In the course of his journey through Central Africa, Dr. A. F. R. Wollaston, who formed one of the party which set out from England to climb the Ruwenzori, has discovered a new race of pigmies. Upon the return of the Ruwenzori expedition, Dr. Wollaston, in company with a companion, Mr. Carruthers, set out upon a journey through unknown Central Africa, the wild and inaccessible Mfumbiro country being their especial objective. This region, which lies to the south of Lake Albert Edward, is extremely mountainous, the

villages skirting the mountain slopes below. The expedition spent some five weeks among these mountains,



THE CAMP IN THE HILLS.  
THE NILE-RED SEA RAILROAD.

the north, the intention being to reach Warman rocks, in the hope of finding water. But the maps were found to be quite unreliable, the rocks being located thirty miles more westerly than indicated by cartographers. The heat was so intense that the party suffered the most terrible privations, and the camels showed signs of exhaustion. After being five days without water, Mr. George, the leader, abandoned all his baggage and returned sixty miles to the south to a water hole in Blood's range. One camel went mad,

and the other animals had suffered so severely that a further wait was essential to enable them to recuperate, while some members of the party were afflicted with delirium. Consequently, the northern journey was abandoned, and the party retraced their steps to a station, suffering intense hardships from want of water. When the station was gained, owing to the precarious condition of one of the two wounded in the encounter with the savages, Mr. George made a flying trip to Alice Springs, in order to send him on

by coach to Adelaide. During this journey the leader contracted dysentery, and died on April 4, 1905. Mr. W. R. Murray was appointed to the vacant post, and after prospecting for several weeks returned to Adelaide, as the camels were so worn out as to be unfit for further work. Gold was found, but not in sufficient quantities to render further prospecting advisable. Those who are aware of the rigors of the desert in the interior consider it remarkable that any member should have survived the ordeal.

# THE ATMOSPHERE OF CITIES.\*

AN INVESTIGATION WITH A PRACTICAL BEARING ON PUBLIC HEALTH.

BY H. HENRIET.

UNTIL a few years ago atmospheric air was supposed to consist of about 79 per cent of nitrogen and 21 per cent of oxygen, with no appreciable admixture of other gases, except small and varying quantities of water vapor and carbon dioxide. In 1895 Rayleigh and Ramsay proved that air contains 1 per cent of an inert gas, which they named argon. Soon afterward Ramsay obtained from liquid air by fractional distillation very small quantities of three other inert gases: neon, krypton, and xenon. Hydrogen and helium, the latter a product of the disintegration of radium, have been obtained from air by the same process.

In addition to these ingredients, which exist in nearly constant proportions at all times and in every part of the world, the atmosphere contains three others which are of immense importance, although they occur in exceedingly small and varying amounts. These are: the vapor of water, which plays a great part in the regulation of temperature and the phenomena of life; carbon dioxide, the principal food of plants; and ozone, which has been regarded as an efficient agent in the purification of the air since 1840, when Schoenbein discovered its presence in the atmosphere.

The chemical composition of the atmosphere is now very well known, but one point has always remained obscure—the alteration of the air by human agencies. This alteration might be assumed to be negligible, in view of the immense mass of the atmosphere, but still it may be asked whether appreciable local alteration does not occur in a large city with its vast population and multitude of chimneys discharging gaseous impurities in great volumes. The depressing effect and relative insalubrity of city air have generally been attributed to organic and other dust, but we shall see that there is also an important chemical difference between the air of cities and that of the country and the sea.

I.

In 1830 Boussingault discovered in the atmosphere of cities and swamps a hydrogenated gas which he supposed to consist entirely of formene, methane or marsh gas,  $\text{CH}_4$ . A few years ago Armand Gautier measured accurately the carbon and hydrogen which exist in mutual combination in the air of cities, fields and the sea. In 100 cubic meters of the air of Paris he found 6.8 grammes of carbon thus combined (about 3 grains troy in a cubic foot). Less carbon combined with hydrogen was found in the country and none at sea. Even sea air, however, was found to contain a little hydrogen which, in the absence of carbon, must exist in the atmosphere in the free state. These experiments led to the extraction of hydrogen from air and they also showed that in cities the atmosphere undergoes notable alterations.

But why are not the contaminations of city air promptly carried away by the winds and mingled with the general atmosphere? I have devoted several years to the study of this question and the mechanism of atmospheric pollution. I will now give a summary of my investigations.

When the proportion of carbon dioxide in the atmosphere is determined by the usual method of passing a measured volume of air through an alkaline solution which is tested before and after the passage, about 3 volumes of carbon dioxide are always found in 10,000 volumes of air. City air, country air, and sea air give very nearly the same result. But when Paris air is confined in a closed vessel for 24 hours in contact with caustic potash or soda a greater proportion of carbon dioxide, often 4 parts in 10,000, is apparently indicated. At a short distance from the city even this method gives the normal proportion of 3 parts in 10,000.

I used a glass globe holding about 12 pints with a device for introducing the alkali without opening the vessel. When the globe was exhausted and filled with pure carbon dioxide mixed with pure oxygen or nitrogen all the carbon dioxide was absorbed in 10 minutes. The fact that a longer time is required when atmospheric air is employed proves that city air contains not only carbon dioxide, but also substances which act very slowly upon alkalis. Again, the fact that even

prolonged contact gives the normal result in the country proves that these substances do not exist there. They must therefore be produced by human agency.

The gases discharged into the atmosphere of cities may be classed as products of respiration and products of combustion. We will first consider the products of respiration.

If two globes are filled with air taken from a room in which several persons have been for a considerable time and one specimen of air is left in contact with the alkali for 24 hours but the other for only 10 minutes (long enough to absorb the carbon dioxide) the alkali will be more affected, indicating apparently a larger proportion of carbon dioxide in the first globe than in the second. The difference may be attributed to products of respiration if it can be shown that these act as weak acids and slowly neutralize alkalis.

When air from the lungs is passed through a condensing worm a liquid of neutral reaction and great deoxidizing power is obtained. When this liquid is distilled over sulphuric acid volatile acids are set free but when it is heated with potash it evolves volatile and strongly basic substances of pronounced ammoniacal odor. This experiment proves that the liquid and therefore the breath contain salts of volatile bases, which may conceivably be slowly decomposed by an alkali, which is thus neutralized by the acid of the salt while the volatile base escapes.

But how can these products of respiration continue to contaminate the incessantly agitated air of the streets? A few experiments will give the answer. If the globe is filled in Paris, in a fog, contact with the alkali for only 10 minutes gives a result which, estimated as carbon dioxide, indicates a proportion of 4 volumes in 10,000, though only the normal 3 volumes are found under the same conditions in the country. We are led to suspect that some of the substances peculiar to the air of cities become dissolved in the fine drops of water that compose the fog and then act upon alkalis very much more rapidly than they act as undissolved gases. In order to test this hypothesis we exhaust the globe and connect it with a long and narrow tube, the free end of which is open to the air of the street. During the filling there is a partial vacuum in the tube, the effect of which is to condense some water which retains the more soluble impurities and allows only the less soluble carbon dioxide to enter the globe. When specimens of air collected in this way are left in contact with the alkali for 24 hours less change is always produced than occurs when the air is admitted directly, without the intervention of the long tube. This proves that condensed water can retain the active substances. On the other hand, if we compress air into a vessel and let it escape in small portions, testing each portion with alkali, we find a gradually increasing effect. Each opening of the vessel causes a sudden expansion and condensation of water, the effect of which is to precipitate the soluble impurities and thus gradually increase the contamination of the air remaining in the vessel. This effect is so clearly marked that if the successive expansions are alternately slow and rapid, so that the condensations are alternately small and great, the quantities of alkali neutralized by the successive portions of air are alternately larger and smaller, though the average quantity steadily increases.

Products of respiration can be detected in the atmosphere of Paris at all times except on dry winter and spring days and after violent southwest gales. Their almost constant presence is explained by the almost constant presence of water drops which carry them down to the lower strata of the atmosphere.

Even in rain and fog the air is not saturated with aqueous vapor. During a long rain storm the relative humidity rises but it never becomes 100 per cent. Members of the Aero Club of Vienna have observed humidities ranging all the way from saturation to below 60 per cent, in clouds, at altitudes between 10,000 and 13,000 feet. Hence it is evident that drops of water can exist in an atmosphere not saturated with aqueous vapor.

Langevin has calculated on thermodynamical principles

that in such an atmosphere drops about 1/100,000 millimeter (1/2,500,000 inch) in diameter can exist in equilibrium, and he has shown that such drops do exist. Aitken had previously proved that dust particles cause condensation and become the nuclei of drops in a supersaturated atmosphere, and Wilson and Elster and Geitel had shown that the atmosphere contains electrified particles or ions which produce the same effect. These ions are much smaller than 1/100,000 millimeter but Langevin has discovered that the air also contains many ions, such as are produced by the oxidation of phosphorus, almost exactly 1/100,000 millimeter in diameter, and hence approximately of the size which theory assigns to drops that can exist in equilibrium in a non-saturated atmosphere. On the hottest days of summer the relative humidity in cities is seldom less than 60 per cent, and therefore the constant presence of fine drops is exceedingly probable. These small drops, like large ones, can absorb soluble gases and carry them to the ground.

II.

We will now examine the contamination of the atmosphere by products of combustion.

When a jet of steam and a stream of Paris air are admitted into a cooled receiver a colorless liquid of neutral reaction is condensed which contains in solution all the soluble ingredients of the air. This liquid is found to contain ammoniacal salts and to have powerful deoxidizing properties. It reduces salts of gold and silver, and potassium permanganate, converts mercuric into mercurous chloride, and gives a red coloration with ferric chloride. These reactions indicate formic acid, which I identified more positively in the following manner.

About 14 gallons of water of condensation were concentrated in presence of pure soda and then distilled with sulphuric acid. An acid distillate having the characteristic odor of formic acid was obtained. Collected in pure soda and redistilled several times with sulphuric acid it yielded a liquid free from organic matter which, on being saturated with baryta water, deposited crystals of a barium salt. When these crystals were weighed and calcined the weight of barium carbonate obtained indicated that the crystals consisted of barium formate and, consequently, that the air contained formic acid.

Formic acid occurs in city air in the form of an ammonia salt, which is found most abundantly in atmospheric water, especially that of fogs. It is found also in the gases of the soil where it is probably produced by fermentation.

But city air contains other deoxidizing substances. With Nessler's reagent pure and very dilute ammoniacal solutions produce a clear yellow tint and formic acid has no effect whatever but atmospheric waters give a muddy color which the addition of acetic acid in excess converts into a greenish yellow tint, resembling that of absinthe and water. This particular reaction does not occur with salts of ammonia or primary amines. It is characteristic of salts of hydrazine and hydroxylamine, and all deoxidizing agents that respond to Nessler's test in the cold.

After long research I isolated and identified the deoxidizing substance thus indicated: 100 liters (220 pints) of the water of winter mist was concentrated on a water bath to 60 deg. Baumé. Part of the volatile substance sought escaped in this operation but nevertheless its solution became more concentrated. When the liquid had been concentrated to half a liter (about a pint) it reduced Nessler's reagent to metallic mercury in a few seconds. The concentrated solution was then distilled. The distillate showed all the characteristics of the aldehydes: reduction of ammoniacal silver nitrate, of Fehling's reagent and of mixed chromic and sulphuric acids, and production of a red-violet tint with rosaniline bisulphite. Treated with hydroxylamine, the solution evolves hydrocyanic acid, which can result only from the dehydration of formaldehyde. When the solution is condensed with dimethylamine dissolved in sulphuric acid, the acid neutralized with caustic soda and the excess of dimethylamine eliminated, an insoluble base can be separated by filtration. This base is tetramethyldiaminodiphenylmethane, as is proved by

\* A lecture delivered at the Sorbonne, Paris, December 18, 1906, and translated for the SCIENTIFIC AMERICAN SUPPLEMENT.



the magnificent blue color (Michler's hydrol) which it yields with acetic acid and lead dioxide.

These absolutely specific reactions make it certain that city air contains formic aldehyde, better known as formaldehyde. M. Trillat immediately suggested that the formaldehyde comes from chimneys, as it is produced in all incomplete combustion. This view has been confirmed by my experiments, which have proved that formaldehyde does not occur in sea air, in soil gases or in products of respiration.

The proportion of formic acid in the atmosphere can not exceed 5 or 6 milligrammes in 100 cubic meters (about 1 grain in 40,000 cubic feet). The proportion of formaldehyde is certainly much greater, though it has not been determined precisely. The acid and aldehyde together, however, cannot constitute more than two volumes in a million volumes of air. This is not surprising, for they are formed in very small quantities in combustion, but it does appear surprising that the carbon dioxide and carbon monoxide which pour in torrents from all chimneys have no marked effect on the composition of the air. We have seen that the proportion of carbon dioxide is sensibly the same in city and country, and Gautier has proved that the air of Paris never contains carbon monoxide.

How can the absence of gases so copiously discharged be reconciled with the constant presence of substances produced in exceedingly small quantities? Here, again, the condensation of water vapor supplies the answer. Formaldehyde and formic acid and its salts are very soluble, and in dilute solution have no appreciable vapor tension at atmospheric pressure and temperature. Hence they are caught and carried downward by drops of water, while the carbon dioxide and especially the nearly insoluble carbon monoxide diffuse rapidly through the general atmosphere and consequently do not long contaminate the place of their origin.

### III.

I endeavored to determine the aggregate amount of the easily oxidized impurities by converting them into carbon dioxide by means of mercuric oxide heated to 250 deg. C. (482 deg. F.). The annual mean proportion of carbon thus found is 1.9 grammes (29 grains) in 100 cubic meters (3,530 cubic feet) of air taken in the center of Paris and 1.3 grammes (21 grains) at Montsouris, at the southern boundary of the city. Gautier found a much larger quantity, 6.8 grammes (105 grains) but he included the carbon of all gaseous compounds except carbon dioxide, while my method included only the easily oxidized compounds, which exert the strongest chemical and physiological action and consequently have the greatest practical importance. This reducing carbon, as it may be called, is most abundant in midsummer when combustion is least. This paradoxical result is explained by the fact that relative humidity and condensation are least in midsummer. The drops formed are small and fall slowly to the ground so that most of the polluting vapors remain in the atmosphere. In winter frequent and copious precipitation and large drops which fall rapidly carry the impurities more quickly to the ground.

Nevertheless, it must be admitted that the atmosphere of Paris is contaminated throughout the year, fogs and mists being the special carriers of pollution in winter, and the clearer air of summer containing a larger proportion of impurities in gaseous form. Hence we may formulate the following general law:

*If a mixture of gases is discharged into the atmosphere of a city, those gases which are insoluble in water at atmospheric pressure become diffused throughout the mass of the atmosphere while the soluble gases are condensed with the water vapor and carried down to the lower strata.*

This statement presupposes that the air is at rest. Let us now examine the effect of winds.

Daily analysis demonstrates the presence of reducing gases in the air of Paris in every kind of weather: dry, wet, calm, and windy. The renewal of the air is probably retarded by buildings but the topographical situation of the city is undoubtedly the most powerful factor. Viewed from the surrounding heights Paris often appears as a great basin half filled with vapors. The winds that sweep over the basin stir but do not remove its contents. Hence we enunciate a second law:

*In a large city, especially if it is situated in a valley, the lower layers of the atmosphere are stirred by the winds but are not renewed as rapidly as they are polluted.*

Sea air always contains water vapor, carbon dioxide and ozone, but it never contains deoxidizing gases. The air of mountains and sparsely inhabited districts approximates to this perfect type. In city air, ozone is found only occasionally and in particular meteorological conditions. Deoxidizing gases occur in so much larger quantities than ozone (1.9 grammes to 2 or 3 milligrammes) that the ozone is entirely destroyed. This disproportion shows that the ozone of the atmosphere can not act as a purifying or health-giving agent where these impurities are generated as they are generated in the interior of large cities.

The general chemical difference between city air and pure air is this:

*The air of the country and the sea always possesses strong oxidizing properties but the air of large cities always exerts a deoxidizing action.*

Here we have a sharply defined difference, which very probably contributes to the known physical inferiority of city dwellers to country dwellers.

### IV.

We have seen that atmospheric ozone is not the effective safeguard of purity that it has been assumed to be. The ozone that exists in country air in the proportion of 2 to 4 milligrammes in 100 cubic meters certainly acts as a powerful antiseptic and remedial agent in pulmonary affections but the occasional or even frequent presence of ozone in a given place is no guarantee of the constant purity or even the average goodness of the local atmosphere. At Montsouris, for example, ozone may be detected every day, but deoxidizing gases are also found. It is extremely improbable that these oxidizing and reducing agents can exist simultaneously in a moist atmosphere, which is favorable to chemical action, and the entire absence of ozone in the center of Paris appears to prove that it is destroyed by the deoxidizing impurities. The solution of the enigma is given by the following experiments. A piece of paper impregnated with starch paste and potassium iodide is exposed to the air at the southern end of Paris (Montsouris). If the wind is south or southwest, that is, if it comes direct from the fields without blowing over the city, the paper gradually turns blue in consequence of the formation of iodide of starch under the influence of ozone. But if the wind veers to the north, so that it comes from the city, not only will the darkening process be arrested but the blue stain will become lighter owing to decomposition of the iodide of starch. Again, suppose that a fresh piece of starched and iodized paper and a porcelain dish containing a few drops of Nessler's reagent are exposed to the air, side by side. With a southwest wind the paper turns blue and no change occurs in the dish, but with a north or east wind the paper remains white while the dish is blackened by a deposit of metallic mercury.

These experiments prove that at Montsouris ozone or deoxidizing gases succeed each other according to the direction of the wind, but never exist simultaneously. Oxidizing and deoxidizing winds alternate, and the occasional presence of ozone does not prove that the air is always pure. This condition is better than constant impurity, but that is all.

Hence we have the following criterion of a pure atmosphere:

*The atmosphere of a place is free from impurities generated by human agglomerations if it always contains more or less ozone and never shows a trace of deoxidizing gases, especially formaldehyde.*

The production of the ozone to which the oxidizing properties of pure air are due was first attributed to the electric sparks and silent discharges of thunder storms. When it was learned that ozone is always present in pure air this explanation became inadequate, and the origin of atmospheric ozone was sought in the slow combustion which takes place in the surface soil and in growing plants, as it was known that flames generate ozone if the surrounding air is cooled very quickly and that the slow combustion of phosphorus is always accompanied by the production of a small quantity of ozone.

To me these theories appear to have little foundation. The formation of ozone in or upon the ground or in forests has never been proved. It has been asserted that the curative effects of pine forests are due to the production of ozone in the oxidation of terebinthines, but the methods of experiment employed do not inspire confidence in their results. Besides, it appears strange to assume that ozone is produced in the soil, which is the medium most destructive to it. If it is so produced, moreover, the proportion of ozone in the atmosphere should diminish as we ascend, but the reverse is the fact. On the same day Maurice de Thierry found 9.4 milligrammes of ozone in 100 cubic meters of air on the Grands Mulets, at an altitude of 9,900 feet, but only 1.9 milligrammes on the low hill of Montsouris.

At Montsouris the southwest wind brings the largest proportion of ozone, although all southerly winds escape the contamination of the city. Rain is another important factor. Every shower is accompanied by an increase in ozone.

From experiments yet unpublished I conclude that the southwest wind brings to the ground air from the upper regions of the atmosphere. Rain probably has the same effect. Hence it may be inferred that the ozone is formed in these upper regions, probably under the influence of solar rays or of the silent electric discharge that may go on incessantly in highly rarefied air, as has been proved by Bouty's experiments on the limit of the dielectric state in gases.

### V.

Now that we know how the atmosphere of cities is polluted it becomes possible to formulate practical advice for the future avoidance of the deplorable results of present conditions. In the first place it is evident that a depressed basin is an improper location for a

city. Cities should be built on hills or plains. Unfortunately, however, economical considerations must prevail, and the site of a city must be determined by the proximity of fertile districts and facility of communication by water and railway. But at least the salubrity of the city can be improved by laying out its streets in the direction of the strongest winds. The obstacles offered to the circulation of air should also be diminished as far as possible by widening streets and decreasing the height of buildings so that even if the city is situated in a "pocket" the lower strata of the atmosphere can diffuse freely into the purer air above.

Inhabited rooms and buildings, which are always contaminated by deoxidizing products of respiration, should be aired very frequently. As formaldehyde is a powerful deoxidizing agent and one of the constituents of foul air, apartments in which it is used as a disinfectant should be temporarily vacated. For continuous purification of the air in inhabited apartments apparatus which evolves formaldehyde is very objectionable. The proper agent for this purpose is ozone, which is indicated by Nature itself. Its employment is hardly practicable at present but it may be replaced by sunlight. It is now known that the atmosphere is the seat of radiant energy of diverse form and origin. From the earth rise those radioactive emanations of which the physiological effects are now under investigation. The luminous rays of the sun have been studied to such good effect that phototherapy, or the treatment of various diseases by light, is now an established branch of therapeutics, and the ultra-violet rays possess strong bactericidal properties, of which we can avail ourselves only by opening our houses freely to the sunlight.

### PAPER PULP FROM BAMBOO.

With a view to encouraging the native paper-making industry, and particularly the preparation of pulp from the bamboo plant, in Burma, the Indian government has announced a number of concessions. The paper-making industry in the country is considerably handicapped by the paucity of the requisite raw material, a large proportion of which must be imported from abroad to be mixed with the local supplies. At the same time the valuable qualities of the bamboo fiber have long been known, the Chinese producing some of the finest qualities of paper through centuries past from this fiber. Some years ago an effort was made by an English manufacturer to turn this raw material into paper. He maintained bamboo plantations in Jamaica for this purpose. But the process of pulping the bamboo is attended with many difficulties, as this experiment testified, the greatest being in connection with the separation of the fiber from the gum which causes the fibers of the stalk to adhere together and form the knots. In this instance the bamboo was cut when the plants had attained a height of about ten or twelve feet, and it was found that when the canes grew above this limit the gum hardened so quickly during the growth that the process of separating the fiber from the gum became more expensive. Though the resultant paper was of excellent quality, the attempt to place the industry upon a practicable and commercial footing was abandoned. In Burma vast quantities of bamboo are cheaply available, so that any cheap process that could be evolved for the pulping of the canes would be sure of widespread success. Efforts to achieve this end have been made from time to time, but none has been found to be of any commercial utility. That the gum which forms into the knots so well known in the cane is of an extremely tenacious nature is shown by the fact that a cane has never been known to break at this point. It is therefore apparent that if any means could be found to dissolve this substance so that its nature was still preserved, with a view to its commercial application, a dual advantage would result. The gum could be devoted to some commercial purpose, while the fibers would find a ready market for pulping.

In order to give an impetus to the bamboo pulp process, the government propose to withdraw the tax imposed upon any canes grown and cut for this purpose for a period of twenty-one years; no taxes on such pulp will be charged for a period of seven years; areas for the exclusive cutting of bamboo will be reserved for the mills; free rents for twenty-one years to any mill erected upon government property for the manufacture of bamboo pulp; and the guaranteed free use of all roads leading to and from such a mill. On the other hand, the government stipulates that persons to whom such concessions are granted must erect the mill within two years of the granting of the permit and operate the same at least for 120 days in each year; monthly statements to be rendered to the government concerning the progress and output of the mill; an output of 10,000 tons to be maintained per annum after the end of seven years, to be increased to an annual output of 20,000 tons at the expiry of fourteen years. Many other stipulations of a minor character are imposed, but it is hoped that the efforts of the government to foster a new industry will meet with success.

# VENOMOUS FISHES.

## POISON AS A MEANS OF DEFENSE.

BY DR. A. CALMETTE, DIRECTOR OF THE PASTEUR INSTITUTE OF LILLE.

Among the means of defense possessed by fishes are poison glands so arranged that their secretions can be introduced into the body of an enemy by the teeth, or the spines of the fins or gill covers. The flesh of these venomous species is not, in general, poisonous,

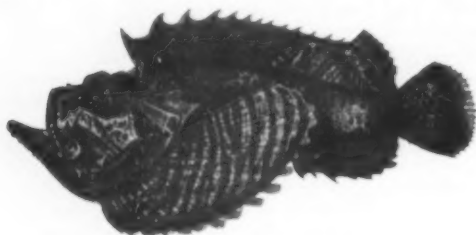


FIG. 1.—SYNANCEIA BRACHIO.

The spines of the dorsal fins are poisoned.

though many fishes which have no power to inflict wounds are poisonous when eaten.

One of the most interesting of venomous fishes is the synanceia (*Synanceia brachio*, Fig. 1). This is the *Crapaud de mer* (sea toad or toad fish) of Reunion, the *taffe* of Mauritius, the *Ikan-salan* (devil fish) of Java, and the *noku* of Tahiti, and is found almost everywhere in the Indian Ocean and the hot regions of the Pacific, where it lives buried in the sand of coral reefs except when it darts from its lurking place to attack its prey. There are many local varieties, some of which attain a length of 18 inches. The thick and sharp spines of the dorsal fin are grooved on each side, and each spine bears, near its middle point, a double poison gland or sack, which, on being subjected to pressure, discharges its secretion into the grooves. The expulsion of the venom is not a voluntary act, nor can it be provoked by any irritation short of actual pressure on the gland. When the bare foot of a fisherman or bather, however, is planted on the back of the hidden fish, a painful wound is produced and serious illness or even death may result.

The venom, when extracted from the gland, is a limpid, bluish, slightly acid liquid. Introduced into the leg or arm it causes very acute local pain, which gradually extends over the entire limb. The pain is so agonizing that it sometimes produces delirium, in

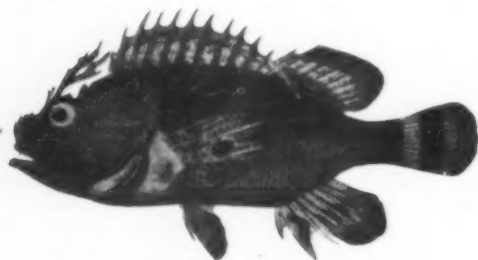


FIG. 2.—SCORPOENA GRANDICORNIS.

Its poison inflicts agonizing pain.

which the sufferer strikes and bites his attendants. Other patients insist on the amputation of the wounded limb, and some have been known to perform the operation themselves. Some cases terminate in fatal syncope. In others, ulceration, gangrene, and blood poisoning ensue. The wounds heal very slowly, especially when, as is usually the case, they occur on the soles of the feet. One drop of the venom injected into a frog causes death in a few hours.

The rascasse or scorpene is almost as dangerous.

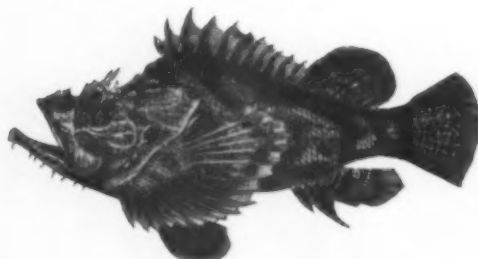


FIG. 3.—SCORPOENA DIABOLUS.

Its venom may cause death.

The West Indian species (*Scorpoena grandicornis*, Fig. 2) is a fish from 12 to 20 inches long, with a red back and yellow belly and eyes. The East Indian and Pacific species (*S. diabolus*, Fig. 3) is red and brown, with oblique white and brown stripes. The

smaller Mediterranean species (*S. porcus*) enters, under the name *rascasse*, into that famous local dish of Marseilles, *bouillabaisse*.

In all three species the head is large, slightly flattened, armed with spines and deeply grooved behind. The poison glands are connected with the spinous rays of the dorsal and anal fins. These rays are closely sheathed by the connecting membrane and each is grooved on both sides. The poison glands are at the inner ends of the grooves. When the spine penetrates the flesh of a victim the enveloping membrane is pushed down upon the gland, which in consequence of the pressure discharges its contents which flow along the grooves under the membrane.

The *pterois*, or fire fish (Fig. 4), is distinguished by the very long and curved spinous rays which protrude from the dorsal and pectoral fins. The color of this singular and beautiful fish varies from red brown to bright rose. It is a native of the Indian and Pacific oceans. The poison is secreted at the base of the dorsal rays.

A venomous fish very common in European waters is the weaver, sting bill, or sea cat. The name weaver



FIG. 4.—PTEROIS (FIRE FISH).

The poison is secreted at the base of the dorsal rays.

is a corruption of the French name *vive*, which is given to this fish because of its great tenacity of life out of water. The weaver has two sets of poison glands, situated at the base of the dorsal rays and on the gill covers. Each of the latter bears a spinous process which has two longitudinal grooves connecting with a conical cavity in the base of the opercular bone where the poison gland is situated. The secretion has been studied by several investigators.

Briot, in order to obtain a sufficient quantity for experiment, excised the poison spines and adjacent parts, ground them in a mortar and extracted them with pure glycerine. A few drops of the filtered solution sufficed to kill a rabbit or a guinea pig. Immediately after the injection had been made in the thigh the animal became affected with paralysis of the foot and tetanic convulsions. An eschar formed twenty-four hours later and death intervened on the second or third day. Briot succeeded in establishing



FIG. 5.—BATRACHUS GRUNIENS (GRUNTING TOAD FISH).

Each of the three spines of the anterior dorsal fin and the spine at the top of the gill has a poison sack at its base.

tolerance of the poison by repeated injections and obtained, from rabbits thus treated, a serum capable of neutralizing the poison and making rabbits immune to primary inoculation with several times the normally fatal dose.

Several other venomous fishes are found distributed in tropical waters. The grunting toad fish or frog fish (*Batrachus grunniens*, Fig. 5) is particularly abundant in the West Indies. It is a little fish, rarely exceeding 12 inches in length. When it is taken from the water it makes a peculiar grunting sound which has given it its specific name. The pectoral fins are of a reddish tint, the back brown, and the sides yellow, veined with black. Each of the three spines of the anterior dorsal fin and the spine

at the top of the gill cover has a poison sack at its base.

The *Thalassophryne reticulata* (Fig. 6) which abounds along the coasts of Panama and Brazil is provided with a similar venom-producing apparatus.

Some of the bright colored, short, deep, and narrow fishes known as squammipennes, or scaly-finned fishes, are reputed to be poisonous. The *Holocanthus imperator* (Fig. 7) of the Malay archipelago is an example. The dorsal and anal fins of these fishes

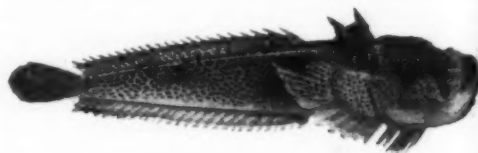


FIG. 6.—THALASSOPHRYNE RETICULATA.

have very sharp spines, but it is not proved that they are provided with poison glands.

The murena is an eel-like fish, and its naked skin, like that of the true eel, is covered with a thick layer of viscous mucus. The mouth is furnished with one or two rows of long, curved teeth and the skin is marked with bright colors in patterns which differ greatly in different species. The murena, which sometimes exceeds six feet in length, lives in deep water and feeds on fishes and crustacea. The tropical species often invade fresh water streams. *Murena moringa* (Fig. 8) is found in tropical Atlantic waters. The flesh of the Mediterranean species (*M. helena*) is very delicate and was highly esteemed by the gourmets of ancient Rome.

The poison apparatus of the murena, like that of snakes, is situated in the mouth. It consists of a gland or pouch in the roof of the mouth, of a capacity of half a cubic centimeter, and three or four conical teeth, curved like the fangs of snakes. But the teeth are solid, not tubular, and the venom flows between them, and the mucous membrane which ordinarily sheathes them is pushed back to their roots as they penetrate the flesh of the victim. The venom evidently possesses digestive as well as poisonous properties, for

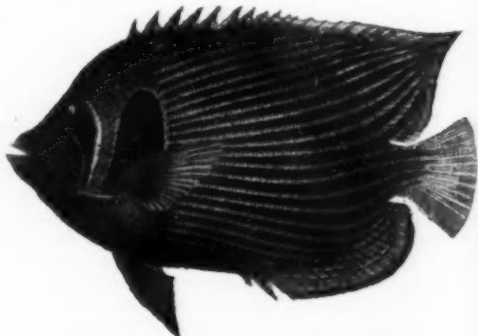


FIG. 7.—HOLOCANTHUS IMPERATOR.

it digests the poison gland, which cannot be found except in freshly-killed specimens.

The venoms of all the fishes which I have mentioned are very similar in their effects, which differ only in intensity. They have not yet been thoroughly studied and a fuller knowledge of their properties is greatly to be desired.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *La Nature*.

**Bleaching Vegetable Fibers.**—Place fabrics in a hot bath (140 deg. F.) of 2 to 3 per cent hydrochloric acid; after 24 hours transfer to a 2 per cent solution of bromine. Herein it is kept in constant motion for 24 hours, taken out and the bromine, at 4 to 5 intervals, each of



FIG. 8.—MURENA MORINGA.

The poison apparatus is situated in the mouth.

2 to 3 hours, saturated with very dilute soda lye. Allow to remain in this bath 12 hours, then rinse in 1 per cent soda lye and finally in clean water. Dry first in the open and then in a current of air at 104 deg. F.



# ARTIFICIAL FERTILIZERS: THEIR NATURE AND FUNCTIONS.—V.\*

## THE EFFECT OF NITROGEN, PHOSPHORIC ACID, AND POTASH.

BY A. D. HALL, M.A.

BEFORE passing on to the phosphatic manures, it is necessary to consider how far each of the three substances—nitrogen, phosphoric acid, and potash—possesses a specific effect that shows itself in the plant whenever there is either an excess or defect of the particular constituent in the soil. To answer this question properly, we should require to know what is the physiological function of each of these constituents of the plant's food, and though we are still far from any fullness of knowledge, certain general conclusions may be drawn both from field experiments and from the experience of the farm. In the first place, nitrogen is mainly concerned with the vegetative growth of the plant, with the formation of leaf and stem which are the necessary preliminaries to complete development. A deficiency of nitrogen results in a stunted general growth, in which the grain or seed bears a high proportion to the whole weight of the crop; the plant on analysis, however, shows no marked lack of nitrogen as compared with the other constituents. These other bodies, phosphoric acid, potash, etc., in whatever excess they may be present in the soil, are only taken up by the plant as it can use them, i.e., in quantities proportionate to the growth, which in its turn is proportionate to the nitrogen supply. As the amount of available nitrogen is increased the development of leaf and shoot increases, their green color deepens, and maturity tends to become more and more deferred, so that a crop grown on land over-rich in nitrogen always tends to be late and badly ripened and to show a profusion of leaf, characters which, in the case of a grain crop, often result in lodging before harvest.

But the fact that the primary growth of the plant is up to certain limits almost proportional to the supply of nitrogen, so that an application of nitrogenous manure has a quickly visible effect, not only makes it the leading constituent of a fertilizer, but is apt to give it a fictitious importance in the farmer's eyes. The following table shows how with increasing nitrogen it is the straw that benefits more than the grain:

TABLE XIX.—INCREASE PER CENT. FOR EACH ADDITION OF NITROGEN.

	Wheat Grain.	Wheat Straw.
43 lb. N. . . . .	56.3	63.3
86 " " " " . . .	46.4	66.3
129 " " " " . . .	10.4	28.0
172 " " " " . . .	2.7	23.5

As the nitrogen comes to be in excess, various secondary effects manifest themselves, chiefly due to overdevelopment of the vegetative parts of the plant. Flowers tend to double and proliferate, organs like the pales and glumes of barley grow extra stout, and the grain assumes a coarse appearance; at the same time the tissues of the plant are soft and weak, so that it easily falls a prey to fungoid attacks. This latter effect is very palpable on the Rothamsted mangel plots; some of which receive relatively an excessively high amount of nitrogenous manure. On these plots, and only on them, there annually occurs a leaf-spot disease—*Uromyces beta*—which toward the end of the season almost wholly destroys the leaves of the mangels on the high nitrogen plots, whereas it is not to be seen elsewhere. It has been ascertained that the epidermis and other tissues of the leaf are actually thinner in the cell wall when they have been grown with an excess of nitrogen, but this is probably not the main cause of the incidence of the fungoid disease, which is more likely to be due to the formation of a cell-sap more congenial to the fungus. Similarly, among cereals like wheat, rust is always most prevalent on the plots receiving the greatest amounts of nitrogen, or again in seasons or climates giving rise to an exceptionally high temperature of the soil in early spring, so that there is for a time an over-rapid production of nitrates for the plant. For example, in countries where a rainless or a too severe winter compels the sowing of spring wheat late in the season, followed by high temperatures with plenty of moisture, the first growth is extremely rapid, and rust is always very prevalent; over the greater part of South Africa wheat and barley cannot be grown for this reason.

Just as nitrogen delays maturity by promoting growth, phosphoric acid has an opposite effect; it is in some way closely bound up with grain formation, being always found in greater proportions in the reproductive parts of the plant than elsewhere. This ripening action is very clearly seen in the Rothamsted experiments on barley; the plots without phosphoric acid being as a rule about a week behind those which re-

ceive this fertilizer. Naturally, such an effect of phosphoric acid is particularly seen in a wet year when the crop is late to harvest. The following table will illustrate the point: it gives the yield and other particulars of one series of the Rothamsted barley plots in 1893, a specially dry season, and in 1894 which was almost equally wet.

The phosphoric acid increases the proportion of grain

TABLE XX.

	Grain, bushels.		Grains to 100 Straw.		N Per Cent. in Grain.	
	1893.	1894.	1893.	1894.	1893.	1894.
Ammonium salts alone . . . . .	11.6	10.4	85.3	67.5	2.19	1.65
Ammonium salts and superphosphate	18.1	34.9	101.0	77.0	2.13	1.60
Ammonium salts and potash . . . . .	16.8	17.8	85.9	73.8	2.17	1.61
Ammonium salts, super, and potash..	30.8	41.4	102.2	77.7	2.08	1.44

to straw, and decreases the nitrogen content of the grain, and it will be noticed that this latter effect is more marked in the wet season of 1894. Even in the yield itself the phosphoric acid had the greater effect in the wet season.

The action of phosphoric acid on the plant is not confined to its ripening effect; it stimulates the early development of the young seedling to a remarkable extent. Farmers are well acquainted with the good start that any crop gets when manured with superphosphate; indeed it is often used merely to secure a better plant, though with little expectation of otherwise increasing the yield. More than sixty years ago this

of the plant as a whole, yet give rise to a comparatively extensive root development.

To what extent this stimulus to root growth is brought about by other sources of phosphoric acid and under diverse conditions of soil, has not yet been worked out, but there can be little doubt that it explains why a phosphatic manuring has such a valuable effect in establishing the plant, even if the gross yield is not ultimately much enhanced.

It may also go to explain the extraordinary results of quite small dressings of phosphoric acid upon soils in Southern Australia, where a manuring with half a hundred-weight per acre or even less of superphosphate has been found sometimes to double the yield of cereals. On analysis the soils are not rich, but they show no such signal deficiency in phosphoric acid as would account for the action of the manure; it seems much more likely that in a semi-arid country where the whole success of the crop depends on the roots getting quickly down to the cooler and moister sub-soil, the stimulating action of the phosphoric acid upon the young roots becomes of the greatest value. In this connection it may be noted that the two crops which most respond to phosphatic manuring, turnips and barley, are both possessed of shallow roots, confined to a comparatively limited layer of soil; whereas, under ordinary farming conditions, wheat responds very little to phosphoric acid, and mangels hardly at all, both being deep-rooted plants.

It has sometimes been surmised that phosphoric acid is associated with the assimilation of nitrogen by the plant, and particularly with its migration from the stem or roots into the seed, the opinion being probably founded on the fact that the nucleo-proteids, so characteristic of the reproductive parts of plants, contain phosphorus. This opinion is not, however, borne out by the examination of a large number of analyses of barley grain from the Rothamsted plots; when phosphoric acid is deficient, the intake of nitrogen is not proportionally reduced; in fact, the grain grown on the plots not receiving phosphoric acid, is the richest in nitrogen.

The phosphatic manures are practically all compounds of phosphoric acid with lime, and, as is well known, four distinct combinations exist and are found in commerce. Only one, the di-hydrogen calcium phosphate, the characteristic constituent of superphosphate, is to any degree soluble in water; the others give rise to extremely dilute solutions of phosphoric acid, too dilute, as has been shown by experiment, to nourish a plant properly with however large a volume of the solution it may be in contact. Yet insoluble as di, tri, and tetra basic phosphate of lime are, when they are sufficiently finely divided, and well incorporated with the soil so as to be in contact with the roots, they are all effective in supplying the plant with phosphoric acid. An experiment of Kossowitsch's illustrates this point. He had prepared two pots of sand, with which a certain amount of insoluble phosphate was incorporated, and a third pot containing sand alone. In one of the pots containing phosphate certain plants were sown, which were also introduced into the pot of pure sand. But while the former pot was watered with pure water, the latter pot of sand was kept fed with a continuous trickle of water that had flowed through the second sand and phosphate pot without vegetation. Thus, in one case, the roots of the plant were in contact with the ground phosphate, in the other only with the solution arising from it. Of course, both sets of plants were equally furnished with nitrogen, potash, etc., but it was found that only those whose roots were in the same pot with the phosphate made a satisfac-



EFFECT OF PHOSPHORIC ACID UPON ROOT DEVELOPMENT OF BARLEY IN WATER CULTURES.

1	solution contains no phosphoric acid.
2	" " = 1-20,000 normal phosphoric acid.
3	" " = 1-8,000 " " "
4	" " = 1-2,000 " " "
5	" " = 1-1,000 " " "

Other constituents of the solutions alike in all cases.

had been noticed by the late Sir John Lawes; and in one of his earliest papers on "Turnip Culture," in 1847, he writes: "Whether or not superphosphate of lime owes much of its effect to its chemical actions in the soil, it is certainly true that it causes a much enhanced development of the underground collective apparatus of the plant, especially of lateral and fibrous root."

In this statement he was vigorously attacked by Liebig, but some experiments, which are still in progress, show that it was the result of sound observation, and that in some way or other phosphoric acid does stimulate the root development of the young plant. The photograph (Fig. 2) shows a series of water cultures of barley growing in solutions which are alike as far as regards the nitrogen, potash, magnesia, lime,

\* Continued from SUPPLEMENT No. 1643, page 26319.

tory growth; in the other pot the plants were phosphoric acid starved.

This experiment shows that the roots themselves do something toward the solution of the insoluble phosphates, a fact also seen in Czapek's extension of Sachs's original experiment, in which a slab of smooth phosphate placed in contact with the roots of a growing plant, is found after a time to be covered with etched figures of the roots. The view, however, that the solution is effected by the excretion of the acid sap, known to be contained in the roots, is not supported by any evidence demonstrating that such acid can ever get outside the root and into contact with the particles of phosphate; it is the carbon dioxide which the roots are always excreting that brings about the solution of the phosphate. At the point it leaves the root it momentarily forms a concentrated solution possessed of considerable solvent power for phosphates and carbonates.

Since only one of the commercial phosphates is freely soluble in water, yet all of them have to enter into solution before they can be utilized by the plant, the question of their relative availability is not easy to settle, and a variety of solvents have been proposed for its determination in the laboratory. In Germany, for example, basic slag is usually valued, not on the total amount of phosphoric acid it contains, but on the amount that is soluble in a strong ammoniacal solution of ammonium citrate, the idea being that this reagent discriminates between the tri-calcium phosphate, which is insoluble, and the di and tetra calcium phosphates, which will dissolve in the medium. Instead of the ammonium citrate, 2 per cent, 1 per cent, and 0.1 per cent solutions of citric acid have been proposed, and are used by various chemists in valuing phosphatic fertilizers. None of these solvents, however, really discriminate between the different phosphates, all of which are soluble up to a certain point, when an equilibrium is established between the phosphoric acid in solution and that remaining undissolved. If the first solution formed is replaced by a fresh portion of the solvent, more phosphoric acid will come into solution; in fact, all the phosphates are eventually completely dissolved by the solvents in question. The following table shows the amount of phosphoric acid extracted by a 1 per cent solution of citric acid from one of the Broadbalk soils manured for fifty years with superphosphate, the extraction being repeated with fresh solvent as soon as one portion had been saturated and then removed:

100 GRAMS BROADBALK SOIL (PLOT 7) WITH 1 LITRE 1 PER CENT. SOLUTION OF CITRIC ACID.

1st Extraction	56.1 mgms. $P_2O_5$ dissolved
2nd "	22.8 "
3rd "	8.9 "
4th "	6.5 "
5th "	4.4 "
6th "	4.4 "

Very similar results have been obtained when manures are treated in the same manner, and they may be taken to show that a single extraction of any solvent of the kind proposed will not dissolve the whole of a particular compound of phosphoric acid, which may be thereby distinguished from the rest of the phosphates left unattacked. Such a mode of attack should be regarded as affording only empirical figures to assist the analyst in forming a judgment of the manure; and the conditions of making the solution, such as time, shaking, relative amounts of solvent and substance, must be strictly defined. Furthermore, the only solvent which has any *a priori* justification is a solution of carbon dioxide which does the work in the soil; the acids of the cell sap, to resemble which citric acid was taken, have been shown to have no direct contact with the soil particles.

Among the phosphates that are employed as manures, the senior position must be given to bones, the fertilizing properties of which have been known from time immemorial. In the eighteenth century we find that their use was an integral part of "Hertfordshire Husbandry," then perhaps the most advanced farming in the country, and but a little later the Cheshire farmers were beginning to build up the richness of their famous milk pastures by the constant use of the same material. So great was the demand that England soon became an importer of bones, taking in 1822, long before the need for phosphoric acid in the nutrition of the plant had been established, as much as 33,000 tons from Germany alone. Forty years later Liebig was moved to one of his characteristic outbursts on this very point. "England is robbing all other countries of the conditions of their fertility. Already in her eagerness for bones, she has turned up the battlefields of Lepsic, and Waterloo, and of the Crimea; already from the catacombs of Sicily she has carried away the skeletons of many successive generations. Annually she removes from the shores of other countries to her own the manurial equivalent of three million and a half of men, whom she takes from us the

means of supporting and squanders down her sewers to the sea. Like a vampire she hangs upon the neck of Europe, nay, of the whole world, and sucks the heart blood from nations without a thought of justice toward them, without a shadow of lasting advantage for herself!" Well, Germany is paying herself back now by taking our sulphate of ammonia and our basic slag.

Though no longer the unique source of phosphoric acid, bones are still a very important element in the fertilizer trade; last year we imported 47,346 tons, the home production being rather greater. In the main these bones get sold in three forms: after treatment with acid; in the raw, ground-up condition, only the fat having been removed, as bone meal; and thirdly, after they have been degelatinized and the greater part of the nitrogen removed, as steamed bone flour. Raw bones or bone meal, though the price has been at a low level for some years, still seem to be rated too highly; the nitrogen of the phosphoric acid they contain being over-valued if we take into account their availability as shown by field experiments. Practically, all the experiments go to show that bone meal is so slow in its action that quite excessive amounts have to be used and locked up in the soil, if any immediately appreciable result is to be obtained.

Nor is the reason far to seek; owing to the toughness of the osseous structure of the bone it is a matter of difficulty to reduce it to a really fine state of division, at any rate the bone meal of commerce is a comparatively coarse powder. Now it has already been pointed out that a tricalcic phosphate, such as exists in bones, is very far from insoluble in water charged with carbon dioxide, but, as with all sparingly soluble salts, the rate of solution will be proportional, other things being equal, to the amount of surface the solid exposes to attack, and for a given weight of material this increases in the same proportion as the average diameter of the particles decreases. In consequence, for all the insoluble phosphatic manures fineness of grinding is perhaps the most important factor, upon it more than even upon the chemical composition depends the availability of the fertilizer to the plant. Bone meal is slow-acting and ineffective because it is coarse, nor is the valuable phosphoric acid brought into solution more readily in the second year than in the first, because the coarse condition still persists. The availability of a phosphatic fertilizer might even be reckoned as the product of two factors, a solubility factor depending upon its chemical composition, and a second factor—the area of surface of unit weight of the material.

If bone meal has been overrated, on the other hand steamed bone flour has not received the credit it deserves. In the first place analysts have rather warned the farmer against steamed bone flour, as representing in some way a spurious bone meal from which the nitrogen had been illicitly extracted. The warning is needful enough if the steamed bone flour were in any way being passed off as bone meal, but provided it is sold on its own basis as a material containing nearly 60 per cent of tri-calcic phosphate and 1 per cent or so of nitrogen, it is a better manure than bone meal. The fine grinding allows the phosphates to pass into solution, and the ossein of raw bones, in which their nitrogen is present, decays so slowly that it becomes one of the most ineffective fertilizers.

The next phosphatic deposit to receive much attention was guano, which has already been mentioned as a nitrogenous manure. Properly speaking, the term guano should be restricted to material consisting almost wholly of the excreta of sea birds, which has accumulated upon certain oceanic islands in the more rainless districts of the earth, where the birds habitually nest in vast numbers. The best known and richest of these deposits occur off the coast of Peru between the 7th and 20th parallels of south latitude, but similar deposits have been found upon islands on the west coast of South Africa (Ichaboe and Damara Land), the Pacific (Baker, Abrohos, Christmas, and Ocean Islands), Bolivia (Mejillones), the West Indies (Aruba, Navassa, Sombrero), and many other places. The original deposit is mainly a nitrogenous compound, and as may be seen from the analysis previously given of Chinchas guano (a deposit known to have accumulated within the last forty years) it may contain as much as 18 per cent of nitrogen and only 9 per cent of phosphoric acid. The action of the weather, particularly where the climate is not absolutely rainless, is always removing the nitrogenous compounds, so that the proportion of phosphoric acid tends to increase, until even among the Peruvian deposits a guano is found on Lobos Island containing little more than 2 per cent of nitrogen and 60 per cent of phosphate of lime. In some of the other deposits that have been enumerated, Christmas Island, for example, the nitrogen has entirely disappeared and a phosphate rock is left behind, which can only be termed a guano in virtue of its origin. These purely phosphatic deposits, many of which are now exhausted or no longer pay to work, have been so much mineralized that they are not sold as guanos, but are employed for the manufacture of superphosphate. However, the Lobos phos-

phatic guano is still extensively imported, and being naturally soft and in a fine state of division, it can be applied without treatment to the land, and forms one of the most valuable of the neutral phosphates that are so well adapted to light soils. With the exception of the Peruvian deposits and those from the Pacific, Christmas, and Ocean Islands, practically none of the other deposits are now worked.

In 1846, when the use of phosphatic manures was beginning to arouse general attention, Prof. George Henslow called the attention of agriculturists and manure makers to the coprolites which occur over a considerable area of the eastern counties as a bed about a foot thick at the top of the lower greensand formation or at the bottom of the gault. These coprolites, which take the form of pebbles containing 50 to 60 per cent of calcium phosphate and 20 per cent or so of calcium carbonate, consist of concretions of phosphate of lime deposited around excreta, fragments of bone and shell, shark's teeth, etc., and were for many years mined in Bedfordshire, Cambridge, Suffolk, etc.; the output being as much as 50,000 tons per annum in 1884, though now it has entirely ceased owing to the competition of the richer deposits which have become available. Similar deposits were worked in France, Belgium, and Germany, generally in rocks of the cretaceous age, but they attain their greatest development in Florida, Tennessee, and South Carolina. There in many places the subsoil is a sandy deposit full of coprolitic pebbles, which can readily be separated by screens or washing; the beds of the rivers and creeks, again, are wholly composed of the same pebbles which are recovered by dredging. The river deposits have been particularly valued in Great Britain for superphosphate making, because though they only contained about 60 per cent of phosphate of lime they were particularly free from iron and alumina. About 150,000 tons per annum used to be imported, but of late years the supply has been falling off. The various phosphate deposits in North America yielded in 1901 nearly 1,600,000 tons, of which more than half was exported to Europe.

Just as it is impossible to draw a line between the recently formed true guanos and the weathered deposits which have practically become phosphate rock, so again no real distinction can be made between the guanos and coprolites of known origin and the phosphate-bearing strata, which are to be found in many countries, and at all geological horizons. Many of these may have originated in guano beds, others are coprolitic, others again are due to solution of phosphate of lime, originally diffused through a great mass of rock, and its concentration in a single layer. In all cases, however, the material has been of animal origin, whatever processes of solution and redeposition it may have suffered since. In the older rocks the phosphate has often become crystalline, forming the hard mineral known as apatite and mined on a small scale in Canada and Norway. The Estramadura deposits were perhaps the first of the rock phosphates to be described, though they were not much worked until the seventies of the last century. Lahn phosphates from Germany, and the Somme phosphates from the north of France were the most largely exported of these rock deposits, until the first of them was wholly and the latter partially displaced by the discovery of richer American deposits. However, these are now in their turn yielding to the competition of the great deposits of phosphate rock which have been discovered in Northern Africa, and which are now being exported in immense quantities from Algeria and Tunis. The phosphate bed appears to stretch right across the continent, but Morocco has, naturally, not been explored, while the Egyptian rocks as yet examined are hardly rich enough in phosphoric acid for export, though immense beds exist containing 40 to 50 per cent of tri-calcic phosphate. The most important of the phosphate mines in North Africa occur in the province of Constantine in the district of Tebessa, from whence they extend into Tunis, near Gafsa. The rock is generally at the base of the eocene system, and occurs in strata that may be  $2\frac{1}{2}$  or 3 meters thick and contain as much as 60 per cent of calcium phosphate, which may be raised to 70 per cent by picking over. These African phosphates contain but little iron and alumina, and are rapidly becoming the chief material for the manufacture of superphosphate in this country.

The mineral phosphates have been but little employed directly as manures, though there is plenty of evidence that when they are really finely ground they are effective enough on soils retaining plenty of water, and particularly on those of a peaty nature. Recent German experiments also indicate that such ground mineral phosphates are most available when mixed with ammonium sulphate, which, as already explained, acts as a physiologically acid manure and helps to bring the phosphoric acid into solution. In the main, however, the mineral phosphates are used in the manufacture of superphosphate, practically the only manure containing phosphoric acid at all readily soluble in water.

The first published reference to the use of sulphuric



acid to produce a soluble phosphate appears to be in Liebig's Report to the British Association in 1840, in which he recommends that bones should be so treated. However, there is very little doubt that various people in this country had previously made what we now call dissolved bones for agricultural purposes; indeed, in the same year, 1840, Lawes was trying a superphosphate made from bone ash on a comparatively large scale on his own farm. Lawes's private experiments began in 1837, and during the next year he was asked if he could not turn spent animal charcoal, bone char, or bone ash, of which large quantities were available as a waste product in London, into something useful as a manure. He tried it in his plot experiments, and found its efficacy much increased by treatment with sulphuric acid; by 1840 his plot experiments had been exchanged for large scale trials in the field. Lawes took out his first patent for treating mineral phosphates with acid in 1842: "Phosphatic substances have heretofore been employed as manure, but always, to the best of my knowledge, in a chemically undecomposed state, whereby the action on the soils to which they have been applied has been tardy and imperfect. It is in particular well known that in the case of a large proportion of the soils of this country the application of bone dust is of no utility in producing crops of turnips on account of the slow decomposition of bone dust in the soil and the consequent exposure of the young plant for a long time to the ravages of the turnip fly." Lawes found it necessary to disclaim the application of acid to bones in his patent, confining it to "phosphatic substances, apatite, or phosphorite," and it was on this basis his manufactures began. Since also Liebig, in his many controversies with Lawes, never claimed against him any priority in the use of sulphuric acid to dissolve phosphates, it may be concluded that prior to 1840 the use of acid to attack bones was common knowledge, and that Lawes's application of it to mineral substances was his own idea and not derived from Liebig.

At first bone ash and bone char were the phosphatic materials used in the manufacture of superphosphate; then followed the discovery of coprolites, developed in the eastern counties by Packard, after which the various foreign phosphates already enumerated followed in rapid succession. In the manufacture of super a rich phosphate of lime is desirable, containing for the high-grade supers at least 70 per cent of tri-calcium phosphate, with as little oxides of iron and aluminium as possible and a few per cent of calcium carbonate. The latter, though it wastes sulphuric acid by giving rise to an excess of gypsum, results in a dryer and more friable super that can be readily handled in the drill.

The phosphates of alumina and iron are undesirable because they give rise to sulphates of these metals and free phosphoric acid, which, however, slowly change back into the original substances on storage of the manure. Hence the proportion of phosphoric acid soluble in water immediately after manufacture declines, and in its place are found precipitated phosphates known as retrograde or reverted phosphate, which are not taken into account in the British method of estimating superphosphates by the water-soluble phosphoric acid only. The exact value of these phosphates is a matter on which opinions are divided, but at the present time the question is less pressing, because of the abundance of raw material practically free from iron and aluminium. When superphosphate is applied to the soil the soluble phosphoric acid it contains is rapidly reprecipitated; to some extent the clay provides the necessary base, but on most soils the calcium carbonate takes the

ough the precipitation of the phosphoric acid is within the soil may be seen from Dr. Bernard Dyer's examination of the soils from the Broadbalk wheat fields which had been receiving  $3\frac{1}{2}$  hundred-weight per acre of high-grade super for fifty years previously. He found that though the surface soil to the depth of nine inches had been enormously enriched in phosphoric acid soluble in 1 per cent solution of citric acid, the subsoil below had practically gained none, so complete had the precipitation been in the layer stirred by the plow. Again, the drainage waters from these plots show a most trifling amount of phosphoric acid, so that losses by washing out must be negligible. Still more cogent evidence of the retention of phosphoric acid by the soil has been obtained more recently by applying the method of successive extractions with a 1 per cent solution of citric acid until the phosphoric acid going into solution has fallen to the low constant figure indicating the solubility, not of the recently added, but of the original soil phosphates. About five extractions remove the phosphoric acid down to this point; further extractions removing very little more, and the sum of the phosphoric acid dissolved in these five extractions approximates very closely to the surplus of phosphoric acid supplied as superphosphate over that removed in the crop.

This shows that phosphoric acid supplied as superphosphate remains in the surface soil, and in a form that is readily soluble in weak acids such as a dilute solution of citric acid or the natural solution of carbon dioxide occurring in the soil. Doubtless the result would be modified if the soil were not well provided with calcium carbonate, in which case more insoluble phosphates of iron and alumina would be formed. It is a fair conclusion to draw from these results that super, and indeed, all phosphatic manures, may be applied to the land much earlier than is usually the case; because there is not the least fear of their washing out, and it is all important to get them well disseminated through the soil by solution and reprecipitation and by cultivation. For the turnip crop there may perhaps be some advantage in drilling the manure with the seed, so important is it to have the young roots stimulated by an abundance of phosphoric acid close at hand, but with other crops much of the benefit of phosphatic manures is often lost because they are applied when the land has already begun to run short of water. Fine grinding and early application are the two great factors in making phosphatic manures available.

There remain for consideration two other phosphatic manures which form a class apart, in that their reaction is alkaline instead of being acid or neutral as in the cases already dealt with. One of these manures, "basic superphosphate," is manufactured by neutralizing superphosphate with enough caustic lime to precipitate the soluble phosphate as di-calcic phosphate or retrograde phosphate and also to leave a small excess of free lime in the mixture. It is recommended for the lighter soils lacking in calcium carbonate and in consequence unsuited to superphosphate. These soils are also, as a rule, too dry for basic slag. Basic superphosphate has not as yet been put to any systematic test against other sources of phosphoric acid; its fitness of division should, however, do much to make it effective.

In the other alkaline phosphatic manure, "basic slag," the phosphoric acid is supposed to be present as a tetra-calcium compound, which, however, is readily attacked by acids as weak as the solution of carbonic acid in the soil; it is thereby split up into di-calcium phosphate and calcium carbonate, so that in such media it becomes more soluble than tricalcium phosphate. In the basic slag of commerce there is always some phosphorus present as phosphides rather than phosphates, and how far these compounds ever become available for the plant has never been investigated. There is also always in basic slag an excess of lime over that which is combined with the phosphoric acid, silica, etc., but there appears to be little definite information about the amount that is left free in this way. Considering the importance of the basicity of the manure, it is rather curious that so little attention is paid to this point in the ordinary analyses for commercial purposes.

The story of the manufacture of basic slag and of the discovery of its fertilizing properties when merely finely ground has been told so often, and is so much a matter of recent history that there is no need for me to repeat it, but introduced into the fertilizer trade so recently as 1886, at the present time about 300,000 tons are manufactured annually, of which 120,000 are exported.

The immense success of basic slag has in this country been mainly due to its special power of improving a particular class of poor grasslands on clay. The soils of these clays are naturally lacking in both phosphoric acid and carbonate of lime, and when they have been long down to grass they become covered with a thin poor herbage of "bent" grass (*Agrostis*), which creeps along the surface in straggling tufts and affords very poor grazing for any kind of stock. Farmyard manure

and almost any form of nitrogenous fertilizer have no good effects, often an injurious one, but the summer following a dressing of basic slag the whole pasture becomes covered with white clover, small plants of which had previously been living stunted beneath the bents. Stock now graze the land with great relish, and the vegetation year by year improves, the *agrostis* giving place to clovers and other grasses of better character. One of the great factors in this change is the lime in the basic slag. It renders available some of the reserves of potash and nitrogen in the soil, and of the latter there is a great accumulation in any old pasture. Both by its alkaline reaction, its liberation of potash, and the aeration it induces by flocculating the clay when some of the lime is washed into the soil as calcium bicarbonate, it aids the phosphoric acid to render the soil favorable for the growth of leguminous plants, hence the sudden appearance of the hitherto dormant white clover. The white clover is always closely grazed, and as it collects nitrogen from the atmosphere, the whole herbage on the land, grasses as well as clovers, is improved year by year.

On some soils it is well known that basic slag has no visible effect; there is neither the general improvement in the growth of the grass, nor the sudden appearance of white clover which leads to the permanent enrichment. There are three factors which may be operative in bringing about this comparative uselessness of basic slag. In the first place on some soils the dormant plants of white clover do not exist or are present in such small numbers as to be inappreciable in the first year or two following the application of the manure. As Prof. Middleton has shown, it is necessary in these cases to follow up the application of basic slag with a seeding of white clover, harrowed into the land.

Secondly, on sandy soils, with little clay in their composition, there is no reserve of potash compounds to be rendered available by the lime of the basic slag; the Rothamsted experiments show very clearly that it is potash which pushes on the clovers in grass land, and that phosphates do very little for them in the absence of lime, hence when basic slag can act only as a phosphatic manure it will benefit the leguminous crops but little. In such a case potash manures must be used with the basic slag. Lastly, the visible effects of basic slag are always smaller on land newly laid down, simply because there is not the accumulation of nitrogenous material from past crops which characterizes old grass land. The lime in the basic slag renders some of this reserve material available for the herbage, the increased supply of nitrogen being apparent in the fuller green the grass assumes.

It should not be supposed, however, that in any of these cases the basic slag is without value because its application is not visible; phosphatic manures never have the effect upon the growth and color of the crop which nitrogenous manures have, so that they can only be properly judged by the weight and quality of the crop at harvest time.

The question is often raised of how far the improvement effected on grass land by basic slag is permanent and likely to be repeated if the treatment is continued. Only one constituent of a crop is being supplied, the phosphoric acid, whereas potash and nitrogen are also being taken away, having been obtained from the soil through the action of the lime in the slag. When the land is being grazed, however, nearly all the potash and a large proportion of the nitrogen in the grass are returned to the soil in the excreta of the animal; at the same time the clovers are drawing nitrogen from the atmosphere, so that there is no practical loss of fertility. At any rate, feeding out a little cake, which is justified by the improvement in the feeding qualities of the pasture, will more than compensate for any withdrawal of nitrogen. When the land is hayed the case is different, because there is a much greater removal of nitrogen and especially of potash. The Rothamsted experiments show that when only phosphates and potash are supplied to grass land, though the leguminous plants become the characteristic features of the herbage, they cannot collect nitrogen fast enough to furnish a large crop of hay year after year, hence a profitable hay crop cannot be grown continuously without some external supply of nitrogenous fertilizer. When potash also is withheld, the land soon becomes impoverished; with phosphates alone the effect is good at first, but in the end the land becomes poorer than if no manure at all had been supplied, because the draft on the potash and nitrogen originally present in the soil has been increased. Hence, after the first few years, when the reserves of potash in the soil set free by the lime of the basic slag have been somewhat reduced, potash manures will be required. Under more ordinary conditions of farming, when the land is sometimes grazed and sometimes hayed, it may be said that after the first four years or so of great improvement of the land by basic slag, then cake feeding, and perhaps a little nitrate of soda for the hay crop is necessary to keep up the nitrogen supply, and that subsequent applications of basic slag should be accompanied by some potash manure.

TABLE XXI.—PHOSPHORIC ACID SOLUBLE IN FIVE EXTRACTIONS WITH 1 PER CENT. CITRIC ACID COMPARED WITH THAT IN MANURE AND CROP. (Rothamsted, 1904.)

	Phosphoric Acid, lb. per acre.			
	Supplied in Manure.	Removed in Crop.	Surplus in Soil.	Dissolved by 1 per cent. Citric Acid.
Broadbalk, Plot 3 ....	—	550	—550	565
" " 5 ....	3,960	790	3,170	3,000
" " 7 ....	3,810	1,370	2,440	2,470
" " 8 ....	3,810	1,520	2,290	2,055
Hoos, Plot 1 .....	0	555	—555	400
" " 2 .....	3,390	1,200	2,190	2,315
" " 4 .....	3,390	1,240	2,150	2,000

chief part in the reaction, with the production of the di-calcium hydrogen phosphate. As this precipitation takes place all throughout the soil the phosphate is very finely divided and thoroughly disseminated, hence the great effectiveness of superphosphate. How thor-



## ELECTRICAL NOTES.

In order that ships at sea which are equipped with wireless apparatus may obtain the exact time for comparison with chronometers and thus determine accurately their longitude the Dominion government has installed a device at Camperdown, the government station at the entrance to Halifax Harbor, to transmit automatically by wireless the exact time furnished by the government observatory at St. John, N. B. The time signals will be sent each week day morning.

What is considered to be the largest telegraph circuit in daily operation in the world is that between London and Teheran, the capital of Persia, which is some 4,000 miles in length. The line is divided into twelve sections, there being intermediate stations at Lowestoft, whence the line passes for 200 miles beneath the North Sea to Emden, thence to Berlin, across the Russo-German frontier to Warsaw, then running southeast through Rouno to Odessa, thence onward through Kertch, Sukhum Kaleh, Tiflis, and Tabriz to Teheran. At each of these intermediate stations there are repeating instruments and batteries. The Wheatstone automatic receiving and retransmitting system is installed at each station, and thereby messages can be transmitted from one end of the circuit to the other at the rate of from 80 to 400 words per minute according to the nature of the circuit, as compared with 25 to 35 words per minute with the Morse manual transmission. This line, which belongs to the Indo-European Telegraph Company, has been in operation for more than twelve months.

The Munster Schlucht electric railway, traversing the Munster Valley (in Alsace) to a length of 7 miles, has just been completed by the Alloth Electric Company on the Strub system as a combined adhesion and rack railway. The maximum gradient of this railway, 1 meter (3.28 feet) in gage, is 55 per 1,000 on the adhesion section and 220 per 1,000 on the rack section. Current is supplied from a central station erected at Münster, which also supplies light and power to the surrounding country. The alternating current at 7,000 volts generated at the station is transmitted to a transformer, which is situated 4 miles distant on the railway line, and which, besides two converters, contains a buffer battery of 390 cells. The cars are provided with two adhesion motors and two gear-wheel motors, and a special device enables all four motors to be worked on gear wheels when traversing heavy gradients, thus allowing the cars immediately to pass from the adhesion to the rack section. The new railway (the terminal of which is situated on the French frontier on the summit of the Vosges Mountains) connects with the Schlucht-Gérardmer railway. The two lines together constitute, it seems, the first international electric railway system.

Mr. H. P. Taylor contributes to the Electric Journal a paper discussing the errors which may arise by the use of series transformers in connection with instruments for alternating-current measurements. He shows that the current ratio is affected by the impedance of the secondary circuit, and that this variation in ratio changes with the current, being less at full load and increasing as the current decreases. Discussing the same subject in the Journal, Mr. W. H. Thompson explains that the variation in current ratio is due to the fact that the primary ampere-turns must be greater than the secondary ampere-turns by just sufficient amount to make up for the magnetizing component for the core and for the leakage due to cross-magnetism between the primary and secondary coils. Variations make it essential that for accurate measurements the transformer be operated at approximately full-load current, and that for a series of measurements using one transformer the impedance of the secondary be kept constant. It is sometimes desirable, especially in switchboard work on high-tension circuits, to employ one series transformer to operate two or three instruments. In connecting up several instruments in this way it must be remembered that each additional instrument increases the ratio error, and that if any of the instruments have a particularly high impedance the readings of the whole set of instruments will be affected. If accurate measurements involving the use of switchboard instruments are to be made, as in the testing of a power station, the safest method, where several instruments are on one circuit, would be to short-circuit all the instruments but one in taking readings, or to calibrate the instruments and transformer together. Another source of error which should be considered when extreme accuracy is desired in wattmeter measurements, made with a series transformer, is the phase displacement between primary and secondary currents. This displacement is so small in ordinary transformers as to produce no appreciable error in wattmeter readings taken at 100 per cent power factor, but may noticeably affect the measurements on circuits of lower power factor. A phase displacement of 1 deg. will introduce an error of approximately 1 1/2 per cent. The best way to correct readings for this error is to have the wattmeter and transformer calibrated together on a circuit of the same power

factor as the circuit to be measured. While ordinary series transformers have sufficient capacity to carry two or three indicating instruments without serious error, it is not considered satisfactory to operate integrating instruments in the same secondary circuit with other instruments, and they are usually operated from separate transformers or from an independent secondary of a double-circuit transformer. Transformers of this kind are now made having one primary and two secondary windings, each secondary being on an independent core so that the current ratio of one secondary is absolutely unaffected by the load on the other secondary.

## ENGINEERING NOTES.

What Chicago most desires is to have some way by which large deep-sea vessels can have access to the lakes, so that they can load at the lake ports and sail direct for foreign ports. The Chicago River is being deepened by the removal of the tunnels under it, by which the tramcars formerly passed, which only allowed vessels of 18 feet draft to cross. The depth will now be at least 22 feet. The drainage canal is built with the same depth, and it has been proposed to build locks and continue it as a ship canal to the Mississippi, but the International Commission has limited the amount of water to be used in the canal, and many engineers believe that the expense of the proposed undertaking would be too great, as a canal would probably have to be built parallel to the Mississippi—at any rate, as far as St. Louis—as the currents of the Mississippi are continually changing the sandbanks and channels, and in summer, when the river is low, even vessels of light draft have difficulty in passing. The question of jurisdiction over the waters of Lake Michigan is also causing trouble, and may prevent the ship canal being constructed. Canadian interests will be threatened by the withdrawal of too great a quantity of water.

The high-speed locomotive of the future will surely be a four-cylinder balanced compound, using steam of high pressure. Where fuel is extremely expensive, it may be found advantageous to use superheated steam and an improved type of valve motion, but the margin which the compound leaves for economy by these means is so small that it appears to be quite an open question whether the gain in economy offsets the increased first cost and the larger cost of maintenance. For low-speed service there are several possible lines of development. The tandem compound with a rigid driving wheel base is capable of satisfactory service up to considerable power. Where the power required is not excessive, excellent results can be obtained with a single-expansion engine working with superheated steam. This is particularly advantageous in cases where bad water has to be used in the boiler, as the superheating enables a low boiler pressure to be used economically. Where exceptionally great hauling power is required, the Mallet type of compound is undoubtedly the engine of the future. The remarks regarding superheating and special valve motions apply with equal force here.—Cassier's Magazine.

H. J. Small, general superintendent of motive power of the Southern Pacific Railroad, has compiled data showing the great increase in size and capacity of the locomotives and cars of that road. In thirty years the standard locomotive on the Southern Pacific Company's lines has increased in weight from 30,000 to 208,000 pounds. The tractive power has increased in the same time from 11,600 pounds to 43,305 pounds, the latter figure representing the capacity of the heavy consolidated type of engine. Comparisons between the freight car standards of 1888 and those of the present show an increase in weight of freight cars from 22,000 to 42,000 pounds. The capacity has increased from 30,000 to 100,000 pounds. In length the freight car has grown from 27 feet to 40 feet. Passenger car capacities have shown a marked increase also, the statement being made that in twenty-five years coaches have been widened 2 feet, and lengthened 26 feet, the seating capacity increasing from 32 to 70. The height of passenger coaches on the Harriman lines has increased in twenty-five years from 10 feet 9 inches to 14 feet 2 inches, and the weight of coaches has been multiplied by four. While the numerical increase in railroad cars in the United States has been very great, it will be seen that the increase in total capacity is relatively much greater.

Among the new gas engines which are now in use in Germany may be mentioned the Luderitz engines, which have been installed at Cologne, among other places. The engine, which is of 25 horse-power size, is operated by a producer plant on the premises, and this presents some new features. Lignite briquettes are used as fuel, and these are fed in by a hopper having a double gate. When firing up, the necessary air is given by a fan, as in an anthracite producer, but contrary to the latter, the outlet of gas is in the lower part. For large plants, the water feed for the producer boiler is regulated automatically according to the consumption of gas, and it thus keeps the same

composition at all loads. After the producer comes a scrubber and a centrifugal washer. One feature is that the pipe leading from the producer to the scrubber is in spiral form and after leaving the scrubber it is inclined so that the water and impurities remain. When the producer has been left burning on a small draft during the night, it takes but three minutes to set it in full working in the morning. After a short stop it is not necessary to have a special blowing in order to go on running. A test made at the works showed that after a stop of thirty-one hours the producer could be started up in four minutes. It can be run day and night for several months without needing to be cleaned.

## TRADE NOTES AND FORMULÆ.

**Preventive for Plant Lice on House Plants.**—Spray the plants with a decoction of 100 parts by weight of quassia wood in 1,000 parts of water.

**Plant Lice Tincture.**—5 parts of green soap, 5 parts of tobacco extract, 80 parts of tincture of quassia, 30 parts of ordinary alcohol, 5 parts of sulphate of copper.

**Lead Pencil Eraser.**—Dissolve gum rubber in sulphide of carbon until a fluid of even consistency is obtained, then thicken with starch to make a dough; allow the sulphide of carbon to evaporate in the open air. Finely pulverized pumice stone may be added to the starch.

**Bleaching of Delicate Fabrics.**—The goods must be washed and boiled, then transferred to a warm bath of 500 parts of water and 2 parts of permanganate of potash. In this it must be left for an hour, always under water. It is then transferred to the second cold bath of 500 parts of water, with 50 parts of sulphurous acid, in which it must remain covered for 3 to 4 hours. To be then dried in a warm place.

**Lead Varnish, Black.**—Heat 100 parts of lead-linseed oil varnish until it begins to emit vapors, add 15 parts of litharge, or red lead; after this has dissolved, 1.5 parts of flowers of sulphur. Constantly stirring, it is boiled for 1/2 to 1 hour, and a quarter of an hour before boiling is concluded add another two parts of litharge, after which it is allowed to cool, and the thickly fluid mass, when cold, diluted with a sufficiency of oil of turpentine to make it available for painting purposes.

**Bleaching Animal Fibers.**—The material, freed from sweat, fat, gum, etc., is placed in a bath in which a little finely ground indigo (1/2 part to 1 part in 100,000 parts of water) is suspended. Then the spun fibers are placed from 24 to 48 hours in an aqueous solution of hydrosulphite of sodium, to which acetic acid has been added. To each 1,000 parts of the 1 to 4 deg. B. solution we take 5 to 20 parts of 50 per cent acetic acid, expose to air, then wash, first in a weak soda solution, then in clear water, and finally dry at 86 deg. to 95 deg. F.

**English Biscuits.**—125 parts sugar, 125 parts butter, 125 parts flour, 125 parts raisins, currants, and candied lemon peel (citron), 20 parts of shaved almonds, a pinch of caraway seeds, some scraped citron rind, 6 whites of eggs, 8 yolks. The butter is cut with flour into small cubes. After the white of egg has been whipped into a stiff cream, stir in first the sugar, then the raisins, etc., mix in the flour with the butter and last of all, the yolks of eggs, fill the mixture into small longish dishes, bake at a medium heat, and glaze with vanilla glazing.

**Cold-Liquid Grafting Wax.**—I. Dissolve 1,250 parts by weight of rosin, 200 of black pitch, 120 of linseed oil, 50 of common turpentine, 130 of yellow wax with gentle heat; leave to cool, stirring constantly, till the mass begins to get stiff, and then stir in 400 parts of spirit (alcohol). Continue the stirring till cold. The grafting wax must be kept in closed tin boxes.

II. Melt slowly 500 parts by weight of Burgundy rosin; remove from the fire and stir in 70 to 80 parts of 90 per cent spirit. Keep in wide-necked glass vessels or tin cans.

III. 10 parts of rosin, 1 of turpentine, 4 of spirit. Stir in the spirit last.

IV. 35 parts of rosin, 25 of yellow wax, 15 to 20 of methylated (denatured) spirit.

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